

Wilmington Facility Wilmington, MA

Olin Corporation

PRINTED ON

JUN 25 1993

# COMPREHENSIVE SITE ASSESSMENT PHASE II FIELD INVESTIGATION REPORT VOLUME I (Text and Appendix A through D)

Wilmington Facility Wilmington, MA

Olin Corporation

#### **EXECUTIVE SUMMARY**

A Phase II Comprehensive Site Assessment (CSA) program was designed and implemented by Conestoga-Rovers & Associates (CRA), on behalf of Olin Corporation (Olin), at the former production facility (Facility) located at 51 Eames Street, Wilmington, Massachusetts. The objective of the CSA was to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. This report, prepared by CRA, presents a summary of the data collected, its evaluation and conclusions drawn from the Phase II CSA activities conducted at the Facility. A risk assessment for the Facility, based on the CSA data, has been prepared by Asea Brown Boveri (ABB) and is presented under separate cover.

The Facility, from its construction in 1953, historically manufactured chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry. Prior to 1970, all liquid wastes generated at the Facility were discharged into a series of unlined pits in the central portion of the Facility. In 1970, a neutralization system including two lined lagoons was completed. Acidic waste streams were neutralized with lime and discharged to the lined lagoons with the supernatant pumped through a clarifier before discharge. The solids (calcium sulphate) from the lined lagoons were periodically dredged from the lined lagoons and landfilled on the southwest corner of the Facility (Sulphate Landfill). The lined lagoons were removed and the Sulphate Landfill was closed in 1986 when operations at the Facility ceased.

Annual monitoring performed at the Facility in 1990 indicated that past operations and disposal practices at the Facility had resulted in off-site groundwater contaminant migration to the west of the Facility. In response to these data, Olin retained CRA to prepare and complete a Phase II Comprehensive Site Assessment for the Facility.

The CSA identified the following geologic units at the Facility, in descending order of age, as glacial outwash, glacial ice contact deposits; glacial till, and fine grained sedimentary gneiss. The glacial ice contact deposits and glacial outwash function as the single, principal hydrostratigraphic unit in the area of the Facility. The uppermost fractured portion of the bedrock is considered part of this flow system. Below the upper fractured bedrock, little groundwater is transmitted along small fractures and joints.

The Facility and surrounding area encompasses portions of two hydrogeologic basins with the divide separating these two basins located west and north of the Facility. East of the divide, the general groundwater flow is from the northwest to southeast across the main part of the Facility and ranges between 10 feet and 325 feet per year. West of the divide, the groundwater flow ranges between 10 feet to 425 feet and is directed to the west into the main portion of the regional aquifer. Closely paralleling the groundwater divide is a surface water divide separating the watersheds of the Ipswich and Aberjona Rivers.

A dense groundwater plume, approximately 20 feet thick beneath the Facility, is observed from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges east just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill. Frequently detected Facility-related compounds detected in the groundwater include Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs) and inorganic compounds. The VOCs and SVOCs are mainly limited to the Facility. The inorganic compounds ammonia, chloride, chromium and sulphate are the major compounds associated with the off-site dense plume.

Three factors believed to have had the major influence over migration of the dense contaminant plume in the aquifer, are the slope of the bedrock surface; the hydraulic forces generated from recharge of the contaminants; and the dilution effects at the plume edge which control pH.

The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources: the discharge of yard and process spills and oily wastes to Lake Poly, the disposal of organic wastes to the unlined pits, and the disposal of drums containing organic compounds beneath the ground surface.

The inorganic contaminants found in the groundwater are most likely attributable to wastewater which was directed into a series of unlined pits and the unlined Lake Poly located in the central portion of the property.

The organic contaminants found in the area of monitoring well GW-49 east of the Facility, indicate an off-site source of organic contaminants is present, since no apparent correlation can be made between the Facility-related organic compounds and the organic compounds detected in well GW-49.

There are three areas at the Facility which exhibit evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. Materials within the test pits of the three areas have been identified as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine). Organic compounds B2EHP, NNDPA and NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate are the major compounds detected in the drums and/or soil samples.

The highest concentrations of contaminants in the surface and subsurface soils across the Facility were detected in the vicinity of former Lake Poly. Detected compounds include VOCs, SVOCs and inorganics.

The highest concentrations of contaminants in surface water and sediment were generally detected in the West Ditch and decreased across the Facility. Detected compounds include VOCs, SVOCs and inorganics. Contaminants found in the surface water and sediments are most likely contributable to discharges from process areas into Lake Poly which emptied into the West Ditch.

|     |         |   | <u>Page</u> |
|-----|---------|---|-------------|
| EXE | CUTIV   | E SUMMARY   | i           |
| 1.0 | INTE    | RODUCTION   | 1           |
| 1.0 | 1.1     | CSA PHASE II FIELD INVESTIGATION                              |             |
|     | 1,1     | REPORT ORGANIZATION   | 2           |
| 2.0 | א א פיי |   | 4           |
| 2.0 |         | KGROUND INFORMATIONFACILITY LOCATION AND SURROUNDING LAND USE |             |
|     | 2.1     |   |             |
|     | 2.2     | SITE HISTORY  |             |
|     | 2.2.1   | Ownership   |             |
|     | 2.2.2   | Production Activities   |             |
|     | 2.2.3   | Waste Disposition   |             |
|     | 2.2.4   | Historical Actions  |             |
|     | 2.3     | PREVIOUS STUDIES  |             |
|     | 2.4     | SITE UTILITIES  | 12          |
| 3.0 | REGI    | IONAL SETTING   | 13          |
|     | 3.1     | REGIONAL TOPOGRAPHY   | 13          |
|     | 3.2     | REGIONAL GEOLOGY  |             |
|     | 3.2.1   | Surficial Geology   |             |
|     | 3.2.2   | Bedrock Geology   |             |
|     | 3.3     | REGION AL HYDROGEOLOGY  |             |
|     | 3.3.1   | Overburden Hydrogeology                                       |             |
|     | 3.3.2   | Bedrock Hydrogeology  |             |
|     | 3.4     | REGIONAL SURFACE WATER HYDROLOGY                              |             |
|     | 3.5     | WATER RESOURCES   |             |
|     | 3.6     | CLIMATE   |             |
| 4.0 | CC A    | DILACE IL FUELD. A CTIMITUEC                                  | 01          |
| 4.0 |         | PHASE II FIELD ACTIVITIES                                     |             |
|     |         | CSA FIELD ACTIVITIES SUMMARY                                  |             |
|     | 4.2     | TOPOGRAPHIC MAP   |             |
|     | 4.3     | FACILITY MAGNETOMETER SURVEY                                  |             |
|     | 4.4     | FACILITY FIELD TEST PIT EXCAVATIONS                           |             |
|     | 4.4.1   | General   |             |
|     | 4.4.2   | Field Activities  |             |
|     | 4.5     | -WAREHOUSE SOIL GAS SURVEY                                    |             |
|     | 4.6     | WAREHOUSE TEST PIT EXCAVATIONS                                |             |
|     | 4.6.1   | General   |             |
|     | 4.6.2   | Field Activities  |             |
|     | 4.7     | SEISMIC REFRACTION SURVEYS                                    |             |
|     | 4.8     | MONITORING WELL INSTALLATIONS                                 |             |
|     | 4.9     | HYDRAULIC CONDUCTIVITY TESTING                                | 30          |

|     | 4.10                       | SURFACE WATER PIEZOMETER                                |    |
|-----|----------------------------|---|----|
|     | ············ <del>··</del> | AND STAFF GAUGE INSTALLATIONS                           | 31 |
|     | 4.11                       | WATER LEVEL MONITORING                                  | 32 |
|     | 4.12                       | DOWNHOLE ELECTROMAGNETIC LOGGING                        | 33 |
|     | 4.13                       | TEMPERATURE LOGGING                                     | 33 |
|     | 4.14                       | QUALITATIVE BIOTA SURVEY/WETLANDS DELINEATION           |    |
|     | 4.15                       | CSA CHEMICAL SAMPLE COLLECTION                          |    |
|     | 4.15.1                     | Groundwater Sampling                                    | 34 |
|     |                            | 2 Surface Water Sampling                                |    |
|     | 4.15.3                     | Sediment Sampling                                       | 37 |
|     |                            | Subsurface Soil Sampling                                |    |
|     |                            | 4.1 Subsurface Soil Sampling - Physical Characteristics |    |
|     |                            | 4.2 Subsurface Soil Sampling - Chemical Characteristics |    |
|     | 4.15.5                     | 5 Surface Soil Sampling                                 | 39 |
|     |                            | S Air Sampling  |    |
|     |                            | Private Well Sampling                                   |    |
|     |                            | 7.1 Cook Avenue/Border Avenue Wells                     |    |
|     | 4.15.7                     | 7.2 Main Street Wells                                   | 42 |
|     | 4.15.8                     | 3 Town Well Sampling                                    | 42 |
|     |                            | <b>,</b>  |    |
| 5.0 | SITE                       | CONDITIONS  | 44 |
|     | 5.1                        | GENERAL   |    |
|     | 5.2                        | SITE TOPOGRAPHY   | 44 |
|     | 5.3                        | SITE GEOLOGY  |    |
|     | 5.3.1                      | General   | 45 |
|     | 5.3.2                      | Outwash   | 46 |
|     | 5.3.3                      | Ice Contact Deposits                                    | 46 |
|     | 5.3.4                      | Glacial Till  | 46 |
|     | 5.3.5                      | Bedrock   | 47 |
|     | 5.3.6                      | Geologic Summary  | 49 |
|     | 5.4                        | SITE HYDROGEOLOGY                                       | 49 |
|     | 5.4.1                      | General   | 49 |
|     | 5.4.2                      | Hydrostratigraphic Units                                | 50 |
|     | 5.4.2.                     |   |    |
|     | 5.4.2.2                    | 2 - Bedrock   | 51 |
|     | 5.4.3                      | Groundwater Flow System                                 | 52 |
|     | 5.4.3.                     |   |    |
|     | 5.4.3.2                    | 2 East of Hydraulic Boundary                            | 53 |
|     | 5.4.3.3                    |   |    |
|     | 5.5                        | SITE SURFÁCE WATER HYDROLOGY                            | 56 |
|     | 5.5.1                      | General   |    |
|     | 5.5.2                      | West Ditch  | 57 |

<u>Page</u>

|     |  | <u>Page</u>      |
|-----|--|------------------|
|     | FF2 Couch Direk                        | 57               |
|     | # '# '# '                              | 57               |
|     |  | TES              |
|     | - <del></del>                          | 58               |
|     | 5.6.2 Encountered Waste Description    | ı59              |
|     | 1                                      |                  |
| 6.0 |  | 61               |
|     | <del>-</del>                           | 61               |
|     | <b>-</b>                               | 65               |
|     |  | 65               |
|     |  | 65               |
|     |  | 66               |
|     |  | 66               |
|     |  | 68               |
|     | 6.3.2.3 Test Pit 21                    | 69               |
|     | 6.3.2 Test Pit Waste Summary           | 70               |
|     | 6.4 SOIL CHEMISTRY                     | 71               |
|     |  | 71               |
|     | <del></del>                            | 72               |
|     | 6.4.2.1 General                        | 72               |
|     | 6.4.2.2 Surface Soil Samples - Areas 1 | to 1073          |
|     |  | 75               |
|     | 6.4.2.4 Surface Soil Characterization  | Summary77        |
|     | 6.4.3 Subsurface Soil Characterization | 178              |
|     | 6.4.3.1 General                        | 78               |
|     | 6.4.3.2 Characterization               | 78               |
|     | 6.4.3.3 Subsurface Soil Characterizat  | ion Summary81    |
|     | 6.5 GROUNDWATER CHEMISTR               | Y82              |
|     |  | 82               |
|     | 6.5.2 Groundwater Sampling Prior to    | Rounds 1 and 284 |
|     | 6.5.2.1 Indicator Parameter Analyses   | 84               |
|     | 6.5.2.2 Full Parameter Analyses        | 84               |
|     | 6.5.3 Round 1 and 2 Groundwater Da     | ata85            |
|     | 6.5.4 Inorganic Parameters             | 86               |
|     |  | 87               |
|     |  | 91               |
|     |  | 91               |
|     |  | Areas93          |
|     | 6.5.6.1 General                        | 93               |
|     | 6.5.6.2 Inorganic Parameters           | 93               |
|     |  | 94               |
|     |  | nsport95         |

|     |  | <u>rage</u> |
|-----|--|-------------|
|     | 6.5.7.1 Inorganic Parameters                 | 95          |
|     | 6.5.7.2 Organic Parameters                   | 99          |
|     | 6.6 SURFACE WATER CHEMISTRY                  |             |
|     | 6.6.1 General                                |             |
|     | 6.6.2 Surface Water Characteristics          | 101         |
|     | 6.6.3 Surface Water Characterization Summary | 105         |
|     | 6.7 SEDIMENT CHEMISTRY                       |             |
|     | 6.7.1 General                                |             |
|     | 6.7.2 Sediment Characteristics               | 108         |
|     | 6.7.3 Sediment Characterization Summary      | 114         |
| 7.0 | SUMMARY AND CONCLUSIONS                      | 116         |
| 8.0 | RECOMMENDATIONS                              | 121         |

## LIST OF FIGURES

## Following <u>Report</u>

| FIGURE 1.1 | FACILITY LOCATION                               |
|------------|---|
| FIGURE 2.1 | 1992 AERIAL PHOTOGRAPH                          |
| FIGURE 2.2 | FLOOD BOUNDARIES                                |
| FIGURE 2.3 | ZONING DISTRICT MAP                             |
| FIGURE 2.4 | LOCATION OF ACID PITS AND LAKE POLY             |
| FIGURE 2.5 | IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMUs) |
| FIGURE 3.1 | GENERALIZED STRATIGRAPHIC SECTION               |
| FIGURE 3.2 | REGIONAL SURFACE WATER DRAINAGE<br>NETWORKS     |
| FIGURE 3.3 | IDENTIFIED WELLS IN VICINITY OF FACILITY        |
| FIGURE 4.1 | WAREHOUSE TEST PIT LOCATIONS                    |
| FIGURE 4.2 | SURFACE SOIL SAMPLE LOCATIONS                   |
| FIGURE 5.1 | GEOLOGIC CROSS-SECTION A-A'                     |
| FIGURE 5.2 | GEOLOGIC CROSS-SECTION B-B'                     |
| FIGURE 5.3 | GEOLOGIC CROSS-SECTION C-C'                     |
| FIGURE 5.4 | GEOLOGIC CROSS-SECTION D-D'                     |
| FIGURE 5.5 | GEOLOGIC CROSS-SECTION E-E'                     |
| FIGURE 5.6 | - GEOLOGIC CROSS-SECTION F-F'                   |

## LIST OF TABLES

|            |   | Following<br>Report |
|------------|---|---------------------|
| TABLE 2.1  | PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS     |                     |
| TABLE 2.2  | IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMUs)     |                     |
| TABLE 3.1  | SUMMARY OF WILMINGTON TOWN WELLS WEST OF FACILITY   |                     |
| TABLE 3.2  | PRIVATE WELL SUMMARY IN VICINITY OF FACILITY        |                     |
| TABLE 4.1  | CSA FIELD ACTIVITIES SUMMARY                        |                     |
| TABLE 4.2  | TEST PIT EXCAVATION SAMPLE SUMMARY                  |                     |
| TABLE 4.3  | SUMMARY OF HNU SCREENING                            |                     |
| TABLE 4.4  | MONITORING WELL<br>COMPLETION DETAILS SUMMARY       |                     |
| TABLE 4.5  | HYDRAULIC CONDUCTIVITY DATA SUMMARY                 |                     |
| TABLE 4.6  | GROUNDWATER ELEVATIONS SUMMARY                      |                     |
| TABLE 4.7  | PIEZOMETRIC GROUNDWATER ELEVATIONS                  |                     |
| TABLE 4.8  | GROUNDWATER INDICATOR<br>SAMPLING SUMMARY           |                     |
| TABLE 4.9  | FULL GROUNDWATER TCL/TAL PARAMETER SAMPLING SUMMARY |                     |
| TABLE 4.10 | FIRST ROUND GROUNDWATER -SAMPLING SUMMARY           |                     |
| TABLE 4.11 | SECOND ROUND GROUNDWATER SAMPLING SUMMARY           |                     |

## LIST OF TABLES

|            |   | Following<br><u>Report</u> |
|------------|---|----------------------------|
| TABLE 4.12 | FIRST ROUND SURFACE WATER SAMPLING SUMMARY                          |                            |
| TABLE 4.13 | SECOND ROUND SURFACE WATER SAMPLING SUMMARY                         |                            |
| TABLE 4.14 | FIRST ROUND SEDIMENT SAMPLING SUMMARY                               |                            |
| TABLE 4.15 | SECOND ROUND SEDIMENT SAMPLING SUMMARY                              |                            |
| TABLE 4.16 | SUBSURFACE SOIL SAMPLING SUMMARY                                    |                            |
| TABLE 4.17 | SURFACE SOIL SAMPLING SUMMARY                                       |                            |
| TABLE 4.18 | SUMMARY OF DETECTED PARAMETERS TOWN WELL SAMPLES                    |                            |
| TABLE 5.1  | BEDROCK JOINT AND FRACTURE ORIENTATION MEASUREMENTS                 |                            |
| TABLE 6.1  | NATURAL BACKGROUND OF METALS IN SOILS FOR THE EASTERN UNITED STATES |                            |
| TABLE 6.2  | SPECIFIC GRAVITY ANALYSIS SUMMARY                                   |                            |

## LIST OF APPENDICES

| A TOTOTON SENSON A | TOWN WELL/ALTON WELL  |            |
|--------------------|---|------------|
| APPENDIX A         | CONSTRUCTION DETAILS  | VOLUME I   |
|                    |   |            |
| APPENDIX B         | LGI MAGNETOMETER SURVEY REPORT                                    | VOLUME I   |
| APPENDIX C         | LGI SOIL GAS SURVEY REPORT  | VOLUME I   |
| APPENDIX D         | LGI SEISMIC REFRACTION SURVEY REPORTS                             | VOLUME I   |
| APPENDIX E         | MONITORING WELL STRATIGRAPHIC AND INSTRUMENTATION LOGS            | VOLUME II  |
| APPENDIX F         | HYDRAULIC CONDUCTIVITY DATA                                       | VOLUME II  |
| APPENDIX G         | HAGER-RICHTER EM/TEMPERATURE<br>LOGGING REPORTS                   | VOLUME II  |
| APPENDIX H         | QUALITATIVE BIOTA SURVEY/<br>WETLANDS DELINEATION                 | VOLUME II  |
| APPENDIX I         | BOREHOLE STRATIGRAPHIC LOGS                                       | VOLUME II  |
| APPENDIX J         | MAIN STREET PRIVATE WELL SAMPLING PROTOCOL AND ANALYTICAL REPORTS | VOLUME II  |
| APPENDIX K         | CONTAMINANT FATE AND TRANSPORT SUMMARY                            | VOLUME II  |
| APPENDIX L         | COMPLETE ANALYTICAL DATA<br>SUMMARY                               | VOLUME III |
| APPENDIX M         | DATA ASSESSMENT AND VALIDATION REPORTS                            | VOLUME III |

## LIST OF PLANS

| PLAN 1  | UTILITY LOCATIONS                                   |
|---------|---|
| PLAN 2  | TOPOGRAPHIC PLAN                                    |
| PLAN 3  | WELL LOCATIONS                                      |
| PLAN 4  | MAGNETIC GRADIENT MAP INTERPRETATION                |
| PLAN 5  | TEST PIT LOCATIONS                                  |
| PLAN 6  | SEISMIC REFRACTION SURVEY LOCATIONS                 |
| PLAN 7  | SURFACE WATER/SEDIMENT SAMPLING LOCATIONS           |
| PLAN 8  | BOREHOLE LOCATIONS                                  |
| PLAN 9  | CROSS-SECTION LOCATIONS                             |
| PLAN 10 | TOP OF BEDROCK CONTOURS                             |
| PLAN 11 | GROUNDWATER ELEVATIONS<br>DEEP WELLS - 09/03/92     |
| PLAN 12 | GROUNDWATER ELEVATIONS,<br>SHALLOW WELLS - 09/03/92 |
| PLAN 13 | GROUNDWATER ELEVATIONS DEEP WELLS - 04/21/93        |
| PLAN 14 | GROUNDWATER ELEVATIONS<br>SHALLOW WELLS - 04/21/93  |
| PLAN 15 | TOTAL SOIL PARAMETER CONCENTRATIONS                 |
| PLAN 16 | ON-SITE DEEP GROUNDWATER SAMPLING RESULTS           |
| PLAN 17 | ON-SITE-SHALLOW GROUNDWATER SAMPLING RESULTS        |
| PLAN 18 | OFF-SITE DEEP GROUNDWATER SAMPLING RESULTS          |
| PLAN 19 | OFF-SITE SHALLOW GROUNDWATER SAMPLING RESULTS       |

## LIST OF PLANS

| PLAN 20 | CHROMIUM CONCENTRATIONS - DEEP WELLS    |
|---------|---|
| PLAN 21 | CHROMIUM CONCENTRATIONS - SHALLOW WELLS |
| PLAN 22 | SULPHATE CONCENTRATIONS - DEEP WELLS    |
| PLAN 23 | SULPHATE CONCENTRATIONS - SHALLOW WELLS |
| PLAN 24 | CHLORIDE CONCENTRATIONS - DEEP WELLS    |
| PLAN 25 | CHLORIDE CONCENTRATIONS - SHALLOW WELLS |
| PLAN 26 | AMMONIA CONCENTRATIONS - DEEP WELLS     |
| PLAN 27 | AMMONIA CONCENTRATIONS - SHALLOW WELLS  |
| PLAN 28 | pH LEVELS - DEEP WELLS                  |
| PLAN 29 | pH LEVELS - SHALLOW WELLS               |
| PLAN 30 | EXTENT OF CONTAMINANT PLUME             |
| PLAN 31 | CROSS-SECTION A-A' AND B-B'             |
| PLAN 32 | SURFACE WATER SAMPLING RESULTS          |
| PLAN 33 | SEDIMENT SAMPLING RESULTS               |
| PLAN 34 | SURFACE SOIL SAMPLING RESULTS           |

#### 1.0 INTRODUCTION

This report, prepared by Conestoga-Rovers & Associates (CRA), on behalf of Olin Corporation (Olin), presents a summary of the data collected, its evaluation and conclusions drawn from the Phase II Comprehensive Site Assessment (CSA) activities conducted at the Wilmington, Massachusetts Facility (Facility) currently owned by Olin. A risk assessment for the Facility, based on the CSA data, has been prepared by Asea Brown Boveri (ABB) and is presented under separate cover in a report entitled "Comprehensive Site Assessment, Phase II Risk Assessment Report, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation" (CSA Phase II Risk Assessment Report). The location of the Facility is shown on Figure 1.1.

Past operations and disposal practices at the Facility have resulted in groundwater contamination beneath the Facility. In 1986, Wehran Engineering Corp. prepared, on behalf of the Massachusetts Department of Environmental Protection (DEP), a Phase I Facility Inspection Report. Subsequently, the Facility was classified by the DEP as a non-priority disposal site. A waiver of certain intermediate stages of approvals was obtained for the site under the Massachusetts Contingency Plan (MCP) in July of 1989.

Olin has performed annual monitoring at the Facility since 1986. Wells installed in late 1989 and monitoring conducted in 1990 indicated that off-site groundwater contaminant migration had occurred to the west of the Facility.

In response to these data, Olin retained CRA to prepare a Work Plan for a Phase II Comprehensive Site Assessment (CSA). Subsequent to completion of the Phase II CSA Work Plan, Olin retained CRA to carry out field activities required to complete the CSA and ABB to complete the risk assessment as part of the CSA. CRA commenced the CSA field activities in December 1990 and completed all CSA field activities in May 1993. All work

was conducted in accordance with the "Work Plan, Comprehensive Site Assessment (CSA), Wilmington Facility, Wilmington, Massachusetts, Olin Corporation", originally prepared by CRA in October 1990 and revised and finalized by CRA in March 1991. The preparation of this CSA Phase II Field Investigation Report and the CSA Phase II Risk Assessment Report represents the culmination of the Phase II CSA.

The objective of the CSA was to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. The CSA provides the data necessary to be used in developing remedial response alternatives as required by 310 CMR 40.546, Phase III Development of Remedial Response Alternatives and the Final Remedial Response Plan. The CSA also provides the corresponding data under the National Contingency Plan (NCP), 40 CFR Part 300. In November 1992, Olin retained BCM Engineers from Plymouth Meeting, PA to prepare the Phase III Development of Remedial Response Alternatives Report. The preparation of the Phase III Remedial Response Alternatives Report is currently in progress.

## 1.1 CSA PHASE II FIELD INVESTIGATION REPORT ORGANIZATION

The CSA Phase II Field Investigation Report is organized in the following major sections and supporting appendices:

- Section 1.0 presents the introduction to and organization of the CSA Phase II Field Investigation Report;
- Section 2.0 presents background information including Facility history and a summary of its historic data base;
- Section 3.0 discusses the regional characteristics of the Wilmington area including topographic, climatic, geologic and hydrogeologic information;

- Section 4.0 presents a summary of the field activities completed as part of the CSA;
- Section 5.0 presents a summary of physical characteristics of the site (Facility);
- Section 6.0 presents a characterization of contamination at the Facility;
- Section 7.0 provides summary and conclusions based on the CSA Phase II Field Investigation; and
- Section 8.0 provides recommendations for future actions.

As discussed above, in Section 1.0, a risk assessment, based on the CSA data, has been prepared by ABB and is presented under separate cover.

#### 2.0 BACKGROUND INFORMATION

#### 2.1 FACILITY LOCATION AND SURROUNDING LAND USE

The Wilmington, Massachusetts Facility (Facility) occupies a 53-acre site located at 51 Eames Street, Wilmington, Massachusetts. The Facility is bounded on the east by the Boston and Maine railroad tracks, on the south by the Woburn/Wilmington town line, on the west by a Boston and Maine railroad spur and on the north by Eames Street. The location of the Facility is shown on Figure 1.1. The approximate UTM coordinates for the Facility (center of operating Facility area) are 4,710,566.177 northing and 323,074.140 easting. Figure 2.1 presents a copy of the 1992 aerial photograph for the Facility and surrounding area.

Approximately two thirds of the Facility is situated in an area designated as "Zone C" by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program (NFIP). "Zone C" is outside both the 100-year and 500-year flood boundaries. The remaining one third of the Facility, the south-central portion of the Facility, is situated in an area designated as "Zone B" by the FEMA under the NFIP. "Zone B" is outside the 100-year flood boundary but within the 500-year flood boundary. Figure 2.2 presents the flood zones in the vicinity of the Facility, as determined by the FEMA.

The entire Facility is enclosed by an eight-foot high perimeter chain-link fence. The Facility is accessed from the north, off of Eames Street. Access to the Facility is restricted by locked gates when the Facility is unattended.

The Facility is immediately surrounded to the east, north and west by heavy and/or light industrial facilities and to its immediate south by the old Woburn Town Dump.

Further to the west of the Facility, along Main Street, Cook Avenue and Border Avenue, the land use primarily consists of single-family dwellings and some commercial and light industrial development.

Figure 2.3 presents a zoning map for Wilmington for the area immediately surrounding the Facility. As shown on Figure 2.3, the Facility and much of its surrounding area is zoned as General Industrial corresponding to the current land use.

#### 2.2 SITE HISTORY

Information presented in this section has been supplied by Olin Corporation, and is based on Olin's own investigation of the Facility's history.

#### 2.2.1 Ownership

The Facility, currently owned by Olin Corporation (Olin) was formerly owned by Stepan Chemical Company (1968-1980), National Polychemicals, Inc. (1953-1968), and American Biltrite Rubber (for a brief period in 1964). The Facility was closed by Olin in September 1986.

More specifically, from the Facility's construction in 1953 until 1968, it was owned by an entity known as National Polychemicals, Inc. (NPI). It is believed that NPI was initially operated by certain shareholders of American Biltrite Rubber (ABR) from about 1953, and that in 1959, NPI was transferred to American Biltrite Rubber (now known as American Biltrite, Inc.), which continued to operate NPI until 1964. (For approximately one month in early 1964, NPI was dissolved and the Facility was directly owned and operated by ABR.) From 1964 until 1966, NPI was operated by Fisons Limited (now Fisons plc). From 1966 until 1968, NPI was operated by Fisons

Corp., a subsidiary of Fisons Limited. Fisons Corp. merged in 1981 with FBC Chemicals, Inc., which is now known as NOR-AM Chemical Co.

Stepan Chemical Company (now known as Stepan Company) acquired NPI in 1968, and merged NPI into Stepan in 1971. Stepan continued to own and operate the Wilmington Facility until 1980, when it sold the Facility to Olin Corporation. Olin operated the Facility from 1980 until 1986.

#### 2.2.2 Production Activities

The Facility historically manufactured chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry. Table 2.1 presents a summary of Facility's historic processes, based on information currently available, including raw materials, wastes generated and corresponding years of production.

#### 2.2.3 Waste Disposition

Prior to 1970, all liquid wastes generated at the Facility were discharged into a series of unlined pits in the central portion of the Facility or into the unlined Lake Poly located along the western boundary of the Facility. Figure 2.4, taken from a 1970 Wastewater Characterization Study report prepared for National Polychemicals, Inc., by Marine Research Laboratory, New London, Conn., identifies the former location of three pits and Lake Poly. Prior to 1964, with the construction of the two warehouses, two pits can be seen south of Plant C in early aerial photographs. These pits were located in the area of the two warehouses as shown on Figure 2.4. With the construction of the warehouses, in or about 1964, three new acid pits were constructed further south as shown on Figure 2.4.

A process sewer system collected concentrated acid wastes and dilute acid waste including weak acid streams, wash waters from products, filtrate, cooling tower blowdown, boiler blowdown and the pilot lab and discharged to the unlined pits.

It is believed that the unlined pits were associated with Facility production since the start of the Kempore process in 1956. From 1956 to 1967 sodium dichromate was used in the process and acidic waste containing chromium sulphate was believed to have been discharged to the pits and to Lake Poly. About 1967 the Kempore process was changed to use sodium chlorate and discharged acidic waste contained sodium chloride and sodium sulphate rather than chromium sulphate. Kempore was produced in Plant C, Plant C-2 and Plant C-3. The locations of these Plants and the sewer lines which discharged the acid wastes to the acid pits and Lake Poly are shown on Figure 2.4. It should be noted, however, that prior to 1964, two pits were located in the area of the two warehouses shown on Figure 2.4.

A second liquid disposal system collected yard drainage and process area floor drains. These areas collected truck unloading station or process area spills and discharged to the unlined Lake Poly. As mentioned above, it is believed that wastes from the Kempore process in Plant C were also discharged to Lake Poly as were wastes from the Opex process in Plant A which used 415 processing oil.

In 1970 Stepan completed a neutralization system including two lined lagoons. The acidic waste streams were neutralized with lime and the material sent to the lagoons. The supernatant was transferred to a clarifier and discharged "through its property" until the Metropolitan District Commission (MDC) sewer was completed in 1972, at which time it was discharged to the MDC sewer.

Calcium sulphate solids from the lined lagoons were dredged periodically and were landfilled on the southwest corner of the Facility (Sulphate Landfill). National Polychemicals received approval from

the State for plans to construct the Sulphate Landfill in January 1974. Stepan received approval from the State to use the Sulphate Landfill in January 1975.

Subsequent to Olin's purchase of the Facility from Stepan in 1980, Lagoon I was relined in 1981 and Lagoon II was relined in 1983. After Olin discontinued operations at the Facility in 1986 both Lagoons I and II were drained, the water treated to remove sulphate and then discharged to the MDC sewer. The sludge and liners were excavated and taken and disposed of in the Sulphate Landfill.

Waste placement at the Sulphate Landfill ceased in December of 1986. Olin applied to the DEP in 1986 and 1987 to close the Sulphate Landfill and received agency approval on both submittals. Olin formally notified the DEP in 1988 that closure had been completed. The DEP then informed Olin that even though the DEP had previously approved the closure plans, closure of the Sulphate Landfill was not approved.

On March 19, 1992, Olin received a letter from the DEP requesting further documentation of the Sulphate Landfill. Olin met with the DEP and submitted previous information with which to support Olin's position that closure of the Sulphate Landfill was completed in accordance with the approved closure plan.

#### 2.2.4 Historical Actions

The Plant B area has been an area of concern at the Facility. There have been various allegations, in interviews of former employees, of spills in the area, but no documentation of spills exists. Materials allegedly spilled include diisobutylene, diphenylamine, dioctylphthalate and dioctyldiphenylamine, and fuel oil.

When Olin purchased the Facility in 1980 from Stepan Chemical Company, the Plant B tank farm (SWMU No. 23) sat on grade with

no perimeter dike or spill containment system. Olin subsequently installed a secondary containment system consisting of a concrete base slab and perimeter curbing.

In November of 1980, Olin entered into an Administrative Order with the DEP to stop the seep into the East Ditch. Olin installed four (4) pumping wells, between Plant B and the East Ditch, to provide hydraulic containment of the oil seep and extract contaminated groundwater from beneath Plant B. The extracted groundwater was treated and subsequently used in Facility operations as pump seal water.

In 1984, Olin installed five (5) new wells, closer to the East Ditch, to improve the capture of oil identified in the area.

After the Facility was closed in 1986, the extracted groundwater continued to be treated and was trucked to the Greater Lawrence Wastewater Authority POTW. Since October 1987, the treated groundwater has been discharged to surface, in the West Ditch, through a NPDES permitted outfall (SWMU No. 32).

In 1988, Olin installed three (3) large diameter (two 12-inch and one 16-inch) wells to replace the five (5) wells previously installed in 1984. The 1984 wells had begun to plug due to fouling of the screens with iron.

The current treatment system consists of overchlorination to remove ammonia, and granular activated carbon to remove organics.

#### 2.3 PREVIOUS STUDIES

Several studies have been completed at the Facility in the past which document the Facility history since chemical manufacturing first commenced at the Site in 1953. The studies also document hydrogeologic and

environmental investigations which have been conducted at the Facility since 1977.

A Massachusetts Field Investigation Team (FIT) Phase I Site Inspection Report prepared by Wehran Engineering Corp. in 1986 for the DEP presented a discussion of Facility location and description, Facility operational history, and results of past hydrogeologic and environmental investigations along with a Hazard Ranking System (HRS) Score for the Facility.

The Wehran FIT Report was based on Facility inspections conducted by Wehran and an extensive review of historical investigations including the following reports:

- 1. Hydrogeologic Investigation, February 1982, Malcolm Pirnie Inc.
- 2. Report on Groundwater and Surface Water Study, December 1978, Geotechnical Engineers Inc.
- 3. FIT Project Site Inspection Report of Olin Chemicals Group Plant, December 1980, Ecology and Environment Inc.
- 4. Olin Chemicals Annual Groundwater Status Reports.

Further historic information is provided in annual monitoring program reports submitted to the DEP under an Administrative Order. These reports include:

- 1. Olin Chemical Site Wide Hydrogeologic and Surface Water Study: 1986, dated December 5, 1986.
- 2. Groundwater and Surface Water Monitoring Status Report, Olin Corporation, Wilmington, Massachusetts, May 1987.
- 3. 1987 Site-Wide Status Report, Wilmington, Massachusetts, March 1988.
- 4. Olin Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1988, dated January 19, 1989.
- 5. Olin Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1989, dated May 1990.

6. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1990, dated May 1991.

In addition to the annual monitoring program conducted by Olin, as documented in the above referenced reports, Olin has also undertaken the following activities/investigations during 1989 and 1990.

As part of the CSA Work Plan, a total of 34 Solid Waste Management Units (SWMUs), which are historic potential contaminant source areas, were identified by Olin at the Facility. Table 2.2 itemizes the SWMUs and Figure 2.5 locates the SWMUs.

In March 1989, Olin conducted a metal detection survey in an effort to identify potential areas of historic drum burial at the Facility. The results of the metal detection survey are presented Appendix C of the CSA Work Plan.

In May 1990, Olin collected sediment samples from the west and south ditches of the Facility for chemical analyses. The analytical results and sampling locations are presented in Appendix D of the CSA Work Plan.

In October 1990, Olin sampled nine private water supply wells to the west/southwest of the Facility. The samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of the analytical reports are provided in Appendix E of the CSA Work Plan. The type and location of the wells sampled and the analytical results are further discussed herein in Section 4.15.7.

In December 1991, as part of the CSA Phase II, CRA on behalf of Olin, prepared and submitted to the DEP the report entitled "Comprehensive Site Assessment Interim Report". This report documented

CSA activities and provided a hydrogeologic interpretation of conditions at the Facility based on established data at that time.

#### 2.4 SITE UTILITIES

Based on information provided by Olin, historic and existing underground utilities are shown on Plan 1, enclosed and Figure 2.4. All historic underground utilities, identified on Plan 1 and Figure 2.4, which are no longer used by the Facility have been plugged by Olin. All surface and storm water catch basins have also been plugged. There is no point source stormwater discharge associated with the Facility. All stormwater flows off of the Facility in sheet flow run-off. The process sewer connections to the waste treatment plant have also been plugged. Therefore, the historic underground utilities at the Facility are not considered to represent a potential preferential route of migration of contaminants at the Facility. Also, the overburden at the Facility exhibits a hydraulic conductivity in the range of 10<sup>-1</sup> cm/sec to 10<sup>-3</sup> cm/sec (see Section 5.4). Any bedding material which may have been used when installing the underground utilities would probably exhibit hydraulic conductivities on the same order of magnitude. Therefore, the bedding material is not considered to represent a potential preferential route of migration of contaminants at the Facility.

#### 3.0 REGIONAL SETTING

The following regional overview was derived principally from two sources: USGS Water Supply Paper 1694 "Geology and Groundwater Conditions in the Wilmington-Reading Area, Massachusetts" and "Aquifer Protection Study Town of Wilmington", prepared by IEP Inc. in 1990. For purposes of clarification, "Site" refers to the Facility grounds and surrounding region studied as part of the CSA, and "Facility" refers to that portion of the Site which lies within the Facility's property boundary.

#### 3.1 REGIONAL TOPOGRAPHY

The Facility lies in the headwater regions of both the Aberjona River Basin and Ipswich River Basin. The surface water divide for these river basins is positioned just west and north of the Facility. The topography of the area is generally flat and low lying. Elevated areas are scattered across the area where bedrock ridges and knobs protrude from the relatively flat landscape. Surface elevations in the vicinity of the Site range from approximately 78 feet above mean seal level (AMSL) to approximately 82 feet AMSL in the flat low-lying areas to a maximum elevation of approximately 155 feet AMSL at the highest bedrock knob, which lies immediately west of the Facility. Plan 2, enclosed, presents a topographic map of the Facility and surrounding area.

#### 3.2 <u>REGIONAL GEOLOGY</u>

overlying crystalline metamorphic and igneous bedrock constitute the two major geologic units. Figure 3.1 presents a generalized stratigraphic relationship between these units. The following subsections provide a discussion of the surficial and bedrock geology.

#### 3.2.1 Surficial Geology

Regionally, the unconsolidated surficial deposits can be divided into three general units; glacial till, ice contact deposits, and outwash. Organic swamp deposits (peat) exist over much of the area. The parent bedrock of the glacially derived sediment is principally medium to coarse grained crystalline rock and as a result the glacial sediment is also relatively coarse grained. A general description of the three units including discussions of depositional origin, distribution and sedimentary characteristics is presented below.

#### Glacial Till

Glacial till is deposited directly by glacial ice typically at the base of the glacier (lodgement till) and or at the ice margin with little reworking by glacial meltwater (ablation till). In the area of the Site, both till types have been described (see Section 5.3). A lodgement till reportedly overlies bedrock in varying thicknesses up to ten feet thick. This till consists of poorly sorted mixtures of sand, gravel and boulders with a minor component of silt and clay. Lodgement tills are typically dense due to the compressive force of the glacial ice applied to the sediment during deposition.

Ablation till reportedly overlies much of the area, however, it is scattered and difficult to discern from other glacial sediment types. The ablation till consists primarily of sand through boulder sized material.

#### **Ice Contact Deposits**

Ice contact deposits are extensive throughout the area of the Site and are formed where high volumes of meltwater transport and deposit heavy loads of sediment at the immediate margin of the glacier. These deposits consist of poorly to moderately sorted, crudely stratified, mixtures of sand through boulder sized sediment. Ice contact deposits exist in thick packages and are the predominant unit filling some of bedrock valleys which exist in the area.

#### Glacial Outwash

As the glacial ice margin retreated further from the area of the Facility, glacial meltwaters transported and deposited an areally extensive outwash unit. This unit interfingers with and overlies the ice contact deposits in most areas. The outwash unit consists generally of stratified, moderately sorted fine to medium grained sand with minor interbeds of coarse sand and gravel. The outwash, though areally extensive, does not overlie the ice contact deposits in all areas.

#### 3.2.2 Bedrock Geology

Throughout the area of the Site, the dominant bedrock type is dark gray, fine grained gneiss. The gneiss exhibits relict bedding and sedimentary structures and shows mineralogical and textural bedding that suggests a sedimentary rock protolith. A large ridge of this gneiss outcrops along the Woburn/Wilmington boundary as well as in scattered localities across the Site area. In general, the bedrock highs represent zones of greater erosional resistance.

Regional drilling and seismic data shows that the bedrock surface is dissected along zones of apparent weakness into "bedrock valleys". The valleys most likely existed prior to the last glaciation and were further eroded by glacial ice. Regionally, these valleys are associated with fault zones where the bedrock has been weakened by fracturing associated with movement along the faults.

#### 3.3 <u>REGIONAL HYDROGEOLOGY</u>

#### 3.3.1 Overburden Hydrogeology

The regionally extensive glacial fluvial deposits constitute important regional aquifers. Groundwater flow systems in the unconsolidated glacial sediments are closely integrated with the surface water drainage systems with recharge occurring in the upland areas of the basins and discharge occurring to the stream systems. Because the landscape is generally flat and the surface soils are composed primarily of sand and gravel, a high percentage of precipitation recharges the groundwater system.

Groundwater divides closely coincide with the surface water divides. As described in Section 3.4, the major river valleys and their tributaries overlay regional, buried bedrock valleys. The aquifers are thickest in these valleys and provide the principal groundwater resource for local municipalities (see Section 3.5). Hydraulic conductivity values in this aquifer range from 30 to 380 ft/day,  $(1.0 \times 10^{-2} \text{ cm/sec} \text{ to } 1.3 \times 10^{-1} \text{ cm/sec})$  in the ice contact deposits and 0.04 to 114 ft/day  $(1.4 \times 10^{-5} \text{ cm/sec} \text{ to } 4.0 \times 10^{-2} \text{ cm/sec})$  in the outwash (IEP, 1990 p.19).

### 3.3.2 Bedrock Hydrogeology

The bedrock in the area of the Site is moderately to weakly fractured with a zone of higher degree of fracturing found at the top of the bedrock surface. Fracturing diminishes, in general, within five to ten feet of the bedrock surface. Correspondingly, little groundwater is transmitted through the bedrock below the upper fractured surface. Wells completed regionally in the bedrock are typically constructed with several hundred feet of open hole and produce yields adequate for only domestic use. The typical bedrock well yields 0.5 to 60 gpm (USGS-1694, p.17).

#### 3.4 REGIONAL SURFACE WATER HYDROLOGY

The Site lies in both the headwaters of the Ipswich River and the Aberjona River watersheds. The surface water divide separating these two watersheds runs just west and north of the Facility. The principal tributaries which drain the Site and feed these rivers are:

- Maple Meadow Brook which lies west of the Facility and flows north to the Ipswich River; and
- A network of drainage ditches which drain the Facility and flow south to Halls Brook which in turn flows into the Aberjona River.

Figure 3.2 identifies the two drainage basins.

The principal streams which drain the Site, and to some extent their tributaries, are located over buried bedrock valleys which dissect the region. Both the Ipswich and Aberjona Rivers overlie well defined bedrock valleys.

The streams in the area derive their principal component of flow from groundwater discharge. Stream flows fluctuate in response to seasonal changes in evapotranspiration rates, and to some extent precipitation events.

#### 3.5 WATER RESOURCES

Located approximately 4,000 feet northwest of the Facility are three Town of Wilmington well fields at Chestnut Street, Butters Row and Town Park The locations of these wells are shown on Plan 3, enclosed and on Figure 3.3.

The wells are completed in a thick sequence of sand and gravel which fills a bedrock valley associated with Maple Meadow Brook, a

tributary of the Ipswich River. A summary of the Town of Wilmington production wells located west of the Facility is presented in Table 3.1. Construction details for these wells were obtained from Town of Wilmington and are presented in Appendix A.

As shown in Table 3.1, the combined maximum design yield of these wells is 4.6 million gallons per day (MGD) which comprises approximately 49.5 percent of the Town of Wilmington's maximum design yield. However, the average production rate for these wells is approximately 2.3 MGD which comprises approximately 62.2 percent of the Town of Wilmington's average production rate. The discharge from Butters Row, Chestnut Street and Town Park are combined at the Butters Row Treatment Plant for treatment prior to distribution.

The groundwater is initially treated by conventional aeration. Alum, potassium permanganate, and polymer are added to aid in the removal of the particulate matter, followed by granular activated carbon units to remove the remaining organics. The pH is then adjusted with the addition of lime and chlorine gas is bubbled through the water for disinfection purposes.

The Town of Wilmington wells located west of the Facility were sampled by CRA and Coast-to-Coast Analytical Services, Inc. (formerly ABB) personnel during the CSA activities, as discussed in Section 4.15.8.

The sand and gravel aquifer, and to some extent the bedrock, also provide water to private wells located west of the Facility.

Altron Corporation (Altron) located approximately 500 feet west of the Facility currently has two wells in operation which are pumped at approximately 136,000 gpd (communication with Altron 1993). The groundwater is used as non-contact cooling water and a portion is treated for use in its process. The water is then discharged to the Massachusetts

Water Resource Authority sewer system. Available well logs and chemical data from the Altron property are located in Appendix A. It should be noted that a well was constructed at Altron in 1977 in which, upon well development, "green" water was pumped from a depth of approximately 67 feet below ground surface. The "green" water is characteristic of the groundwater plume migrating from the Facility (see Section 6.0). This is noted on a well log located in Appendix A. The location of Altron relative to the Facility is shown on Plan 3, enclosed and on Figure 3.3.

Private well inventories conducted by Olin and CRA over the course of the CSA, identified residences west and southwest of the Facility who have private wells. Table 3.2 summarizes by plot and parcel number, private residences west of the Facility, along Main Street and Cook Avenue and southwest of the Facility along Border Avenue and indicates which residences are connected to town water and which residences have private wells. Figure 3.3 identifies the location of the private residences by plot and parcel number. All of the identified private wells in the vicinity of the Facility were sampled by Olin during CSA activities, as discussed in Section 4.15.7.

The aquifer which occupies the Aberjona River Basin is also considered a primary source of groundwater for the Woburn, Massachusetts region. Currently, however, wells located in the northern portion of the Town of Woburn are not being pumped. Also, in the vicinity of the Site, no private wells were identified to exist in the northern portion of the Town of Woburn.

#### 3.6 <u>CLIMATE</u>

The climate in this region is humid and temperate with fairly uniform monthly precipitation. The average annual precipitation recorded at Reading, Massachusetts is 40.9 inches with October typically being the driest month and April being the wettest. Seventy-five percent of the

precipitation occurs during the frost free season. The mean January temperature is 26.6°F and the mean July temperature is 73.7°F with a mean annual temperature of 49.8°F. The prevailing wind direction is from the west northwest during the winter months, and from the southwest during the summer months with an average windspeed of 7 knots (Hanscom Field Airport, Bedford, Ma).

#### 4.0 CSA PHASE II FIELD ACTIVITIES

As discussed in Section 1.0, the objective of the CSA is to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk or harm, if any, that the Facility poses to health, safety, public welfare and the environment. This section summarizes the investigation activities.

#### 4.1 CSA FIELD ACTIVITIES SUMMARY

The following field activities were implemented/completed during the CSA to collect the necessary data to complete the objectives of the CSA:

- 1. Aerial fly-over and surveying for topographic map;
- 2. Implementation of a magnetometer survey/test pit program to identify any potential buried drums at the Facility;
- 3. Implementation of a soil gas survey/test pit program to identify any potential buried drums beneath the warehouses at the Facility;
- 4. Completion of seismic refraction survey to aide in the determination of bedrock topography;
- 5. Installation of new monitoring wells both on and off the Facility;
- 6. Development and permeability testing of new monitoring wells;
- 7. Collection of potentiometric groundwater elevations to determine groundwater flow rate and direction;
- 8. Downhole electromagnetic (EM) logging and temperature logging to help delineate the groundwater contaminant plume;
- 9. Installation of surface water piezometers and staff gauges to monitor surface water flow:
- 10. Completion of a qualitative biota/wetlands delineation survey;
- 11. Collection of excavated drum samples for chemical analyses;

- 12. Installation of investigative soil borings and collection of subsurface soil samples for chemical analyses;
- 13. Collection of surface soil samples for chemical analyses;
- 14. Collection of groundwater samples for chemical analyses from existing monitoring wells, new monitoring wells, residential and town wells; and
- 15. Collection of surface water and sediment samples for chemical analyses from surface ditches.

The above list of activities includes both those activities identified in the CSA Work Plan and additional activities not identified in the CSA Work Plan. The additional activities consist of above activities 3, 4, 8 and 9. The additional activities also included the completed of additional boreholes and monitoring wells and additional soil, groundwater, sediment and surface water sampling beyond that indicated in the CSA Work Plan.

A summary of CSA field activities including commencement and completion dates is presented in Table 4.1. The following subsections present detailed discussions of the CSA activities. All CSA activities, unless otherwise noted, were conducted in accordance with the protocols/procedures presented the CSA Work Plan.

### 4.2 TOPOGRAPHIC MAP

A topographic map of the Site was prepared by Dana F. Perkins, Inc., Consulting Engineers & Land Surveyors of Reading, Massachusetts as part of the CSA. The topographic map was prepared using aerial photography combined with ground control survey, as required. The topographic map was prepared in two stages. An initial topographic survey of the Facility was conducted in December 1990 and encompassed an area of approximately 130 acres. In December 1991, the topographic survey was expanded beyond the area of the Facility to include an additional 445 acres. In total, the topographic map prepared covers an area of approximately 575 acres.

Plan 2, enclosed, presents the topographic map. The topographic map is drawn at a scale 1"=200' and presents ground surface contours at 1-foot intervals. Vertical control is referenced to mean sea level (MSL) and horizontal control is referenced to USGS datum.

## 4.3 FACILITY MAGNETOMETER SURVEY

From December 14, 1990 through January 8, 1991, LGI, a division of Layne GeoSciences Inc., performed an extensive magnetometer survey of the Facility to determine the potential presence and location of buried drums. A copy of LGI's Geophysical Investigation Report is provided in Appendix B and Plan 4, enclosed, presents a magnetic gradient map interpretation based on the survey.

The geophysical investigation identified a total of 12 anomalies of unknown or suspicious manner which could be potentially associated with buried drums or tanks. The anomalous areas are identified in the Geophysical Investigation Report (Appendix B) and also on Plan 5, enclosed.

# 4.4 FACILITY FIELD TEST PIT EXCAVATIONS

#### 4.4.1 General

Based on the results of the magnetometer survey (see Section 4.3), it was determined that a series of test pit excavations would be completed-to investigate the anomalies of unknown or suspicious manner. Prior to commencing test pit excavations, a report entitled "Work Plan, Test Pit Excavation Program, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation, August 14, 1991" (Facility Test Pit Work Plan), was prepared by CRA and reviewed and approved by Olin. The Facility Test Pit Work Plan included a materials handling plan, sampling protocols, analytical protocols

and a health and safety plan. The Facility Test Pit Work Plan was adhered to during all test pit excavation activities. From October 2, 1991 through October 10, 1991, Clean Harbors of Kingston, Inc. (Clean Harbors) performed the test pit excavation program under the supervision of Olin and CRA personnel.

## 4.4.2 Field Activities

Clean Harbors performed the test pit excavations using a large excavator, a medium sized backhoe, and a small "bobcat" backhoe. The excavator was used in areas of easy access, the backhoe was used where access was restricted by dense vegetation, and the "bobcat" was used in areas where soft wet soil conditions existed. Clean Harbors provided a crew of four people: an excavator operator; two field technicians; and a site supervisor/health and safety officer.

The test pits were advanced by removing approximately two to six inches of soil from the excavation until buried wastes and/or groundwater was encountered. If drums and/or buried wastes were encountered, the excavation was extended in a lateral direction to define the horizontal extent of buried drums and/or wastes.

Twenty-eight test pits were excavated within the 12 anomalous areas identified by the magnetometer survey. One additional test pit was also excavated in an area identified by a former Facility employee as a potential area of drum disposal. Therefore, a total of 29 test pits were excavated at the Facility. Plan 5, enclosed, locates the test pit locations.

In areas where buried drums or visibly contaminated soils were identified, samples were collected for chemical analysis. A total of eight drum and/or soil samples were collected for chemical analysis as summarized in Table 4.2. A representative cross-section of encountered wastes was sampled for chemical analyses in order to provide as complete an

inventory as possible of buried wastes. The presence/characterization of buried drums/waste is discussed in detail in Section 5.6.

Five drums were excavated during sampling and were placed into DOT-approved 85-gallon overpack drums. The drums were moved to a staging area at the Facility, subsequently characterized by Olin and were disposed of off Site, at a facility meeting Federal and State regulations.

# 4.5 WAREHOUSE SOIL GAS SURVEY

From February 5, 1992 through February 7, 1992, LGI performed a soil gas survey beneath the floor of two warehouse buildings at the Facility. The soil gas survey was conducted in an attempt to delineate areas under the warehouses which may be indicative of buried waste. Early aerial photographs of the Facility show two (2) pits behind Plant C with drums clearly present. A later aerial photograph shows the two large warehouses built over the location where the pits had previously been. Interviews by Olin, with previous employees indicated that drums may have been buried under the warehouses during construction. The soil gas survey identified three areas which could potentially be indicative of buried wastes. A copy of LGI's Soil Gas Survey Report is provided in Appendix C.

# 4.6 WAREHOUSE TEST PIT EXCAVATIONS

#### 4.6.1 General

Based on the results of the soil gas survey (see Section 4.5), it was determined that a series of test pit excavations would be completed in the area of the warehouses to investigate the potential of buried wastes. Prior to commencing the test pit excavations, a report entitled "Work Plan, Test Pit Excavation Program, Warehouse Buildings, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation, July 1992" (Warehouse Test

Pit Work Plan) was prepared by CRA and reviewed and approved by Olin. The Warehouse Test Pit Work Plan included a materials handling plan, sampling protocols, analytical protocols and a health and safety plan. The Warehouse Test Pit Work Plan was adhered to during all test pit excavation activities. From July 27, 1992 through July 30, 1992, Clean Harbors performed the test pit excavation program under the supervision of CRA personnel.

## 4.6.2 Field Activities

Clean Harbors performed the test pit excavations using a medium sized backhoe and a "bobcat" loader equipped with a concrete breaker. Clean Harbors provided a crew of four people: a site supervisor; an excavator operator; one field technician/chemist; and a health and safety officer.

At each test pit location, the concrete floor was initially sawcut and then broken up using the "bobcat" loader equipped with a concrete breaker. The concrete pieces were removed using the backhoe and stockpiled at the Facility. The test pits were advanced by removing approximately six to 12 inches of soil from the excavation until groundwater was encountered. All excavated soil was placed on polyethylene sheets immediately adjacent to the excavation. Soil samples were collected from the base of each test pit excavation for headspace screening using an HNu meter. Table 4.3 provides a summary of the HNu meter readings at each test pit location. Based on visual inspection and the HNu screening, no samples exhibited evidence of contamination, therefore, no samples were collected for chemical analysis. Upon confirmation of the absence of drums/drum wastes in the test pits, each test pit excavation was backfilled with the previously excavated material.

A total of nine test pits were excavated within the three anomalous areas identified by the soil gas survey. Figure 4.1 locates the warehouse test pit excavations.

## 4.7 SEISMIC REFRACTION SURVEYS

LGI was also retained to perform seismic refraction surveys at the Site to aid in the determination of the underlying bedrock topography for the selection of monitoring well locations outside of the Facility's boundary. LGI conducted two separate seismic refraction surveys; one in October 1991 and one in February 1992.

A discussion of the methods and results of the two seismic investigations are presented in the reports entitled "Geophysical Investigation, Olin Chemical Facility, Wilmington, Massachusetts, November 1991" and "Geophysical Investigation, Olin Chemical Facility, Wilmington, Massachusetts, March 1992" presented in Appendix D. Plan 6, enclosed, shows the locations of the seismic refraction survey lines.

# 4.8 MONITORING WELL INSTALLATIONS

Monitoring wells were installed on and in the vicinity of the Facility throughout the period of June 1991 to May 1993. All monitoring well installations were completed by Soil Exploration of Leominister, Massachusetts under the supervision of CRA personnel. Prior to drilling at any location, the appropriate Wetlands Commission approvals were obtained by Olin.

A total of 70 groundwater monitoring wells (GW-4D and well nests GW-40 through GW-75) were installed at the Site: 31 monitoring the upper portion of the unconsolidated aquifer (including well GW-62M); 35 monitoring the lower portion of the unconsolidated aquifer and upper fractured portion of the bedrock; and 4 wells monitoring only the upper fractured portion of the bedrock encountered beneath the Site surrounding area.

Plan 3, enclosed, shows the location of all existing monitoring wells and all monitoring wells installed as part of the CSA activities. As part of the CSA activities all existing Facility monitoring wells were inventoried and assessed. Olin secured all existing monitoring wells with lockable caps not already secured and performed any surface repairs required. Table 4.4 provides a summary of all monitoring well construction details. Stratigraphic and instrumentation logs for all wells are provided in Appendix E.

Shallow overburden wells were installed using hollow stem augers (4 1/4-inch inside diameter, nominal 8-inch outside diameter). Each shallow well was constructed of 10-foot long, 2-inch diameter PVC screen and PVC pipe riser. The top of the screen was set approximately one foot above the static water level determined during drilling.

Deep wells were installed to monitor the upper fractured portion of the bedrock and the immediately overlying strata. Temporary 5-inch diameter casing was advanced to the top of bedrock. A corehole was then advanced approximately five feet into the bedrock using wet rotary techniques and continuous sampling with NX size equipment. The core was inspected to determine the depth to the most fractured zone in the 5-foot core. Subsequently, the corehole was reamed out to the base of the most fractured zone using a 5 7/8-inch diameter Tricone drill bit. Each deep well was then constructed of 10-foot long, 2-inch diameter, PVC screen and PVC pipe riser.

Bedrock wells were installed to monitor the fractured portion of the bedrock. Bedrock wells were installed by advancing a nominal 5-inch diameter casing to the top of bedrock. After the 5-inch diameter casing had been set to bedrock, the bedrock was cored using HQ sized coring equipment. The core was logged by the on-Site geologist noting lithology, and pertinent structural geologic features (i.e. fracture and joint style, frequency, and orientation). At a depth where fracturing had diminished, the hole was reamed to a diameter of 4 7/8 inches. Flush threaded 4-inch diameter PVC

casing was then installed and grouted into the reamed bedrock corehole. The casing was allowed to set a minimum of 48 hours to ensure that an adequate seal had achieved.

The well was then further advanced by coring using HQ sized coring equipment. The corehole functions as the monitored zone for the well. The on-Site geologist determined the final depth of the corehole based on the interpretation of the drill core.

At completion, all monitoring wells were secured with lockable caps and locks.

Following installation, all monitoring wells were developed prior to sampling in accordance with the protocols presented in Appendix H of the CSA Work Plan.

All development water from wells located on the Facility was discharged to the ground surface away from the well. All development water from wells located off the Facility was collected in 55-gallon drums and transferred to a tank at the Facility. The development water in the tank was sampled and characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

All remaining soil cuttings from well installations were collected, placed into DOT-approved 55-gallon drums and transferred to a staging area at the Facility. The drummed soils were sampled and characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

#### 4.9 HYDRAULIC CONDUCTIVITY TESTING

Selected overburden monitoring wells were tested for in situ hydraulic conductivity of the screened portion of the aquifer. The tests were conducted by using two methods.

The first method termed a slug test was performed by quickly inserting a PVC rod or "slug" of known volume into the water column within the monitoring well which resulted in a sudden rise of the water in the well in response to the increase of volume. The change in water level over time was recorded using a pressure transducer connected to a data logger. This is termed a "falling head" test. After the well was stabilized, the slug was then quickly removed from the well resulting in a sudden lowering of the water table. The recovery of the water table is then recorded with the data logger. This is termed a "rising head" test.

Because wells responded very quickly to the slug tests (i.e. hydraulic conductivities were too great to collect adequately spaced data), single well pumping tests were then conducted on selected overburden monitoring wells. This test was conducted by pumping the monitoring well using a Grundfos 2.0-inch submersible pump to purge the monitoring well while simultaneously recording the water level response (drawdown) with a pressure transducer connected to a data logger. A maximum pumping rate of seven gallons per minute was achieved with the Grundfos pump. After the well reached stabilization (i.e. drawdown had ceased), the pump was shut off and the resulting recovery was recorded with the data logger.

During the single well pumping tests in the overburden wells, the water levels exhibited very little measurable drawdown when pumped at seven gallons per minute. The wells reached stability soon after pumping commenced indicating high hydraulic conductivities of the screened portion of the aquifer.

Single well pumping tests were also conducted in selected bedrock wells using the same procedure as discussed above for the overburden monitoring wells. These tests generated drawdown and recovery data which indicated very low hydraulic conductivities for the bedrock formation.

The slug test and pumping test data and data interpretation are presented in Appendix F. Table 4.5 summarizes the resulting hydraulic conductivities calculated or estimated.

As summarized in Table 4.5, the horizontal hydraulic conductivity for the monitored intervals of the glacial fluvial deposits (overburden) ranged from  $7.7 \times 10^{-2}$  cm/sec to  $9.7 \times 10^{-4}$  cm/sec, with a geometric mean of  $7.9 \times 10^{-3}$  cm/sec. These data are consistent with the regional hydraulic conductivity data discussed in Section 3.3.

As also summarized in Table 4.5, the horizontal hydraulic conductivity for the monitored intervals of the bedrock ranged from  $1.20 \times 10^{-5}$  cm/sec to  $2.26 \times 10^{-5}$  cm/sec, with a geometric mean of  $1.715 \times 10^{-5}$  cm/sec. These data are consistent with the regional groundwater availability in the bedrock as discussed in Section 3.3.

# 4.10 SURFACE WATER PIEZOMETER AND STAFF GAUGE INSTALLATIONS

A total of ten piezometers and two staff gauges were installed in the West Ditch network and Maple Meadow Brook, respectively, for the purpose of obtaining surface water and groundwater elevation data.

The piezometers installed in the West Ditch network, consist of a 2-foot length of stainless steel "wire wound" well screen coupled and threaded to a 2-inch steel pipe riser. The piezometers were driven by hand into the ditch bottom a minimum of 1/2 foot beyond the top of the

screen. The piezometers were installed in July 1992 by Soils Exploration under the supervision of CRA personnel. The piezometers were installed to assist in the design of an interim action plan to control a white "floc" material surfacing in the drainage ditch west of the Facility. A report entitled "Interim Action Plan, West Ditch Precipitate, Olin Corporation, Wilmington Facility, Wilmington, Massachusetts" dated September 1992, prepared by CRA, was submitted to the DEP in September 1992.

The staff gauges installed in Maple Meadow Brook consist of 4-foot long fence posts. The posts were driven by hand into the stream bottom a minimum of two feet. The staff gauges were installed by CRA personnel in October 1992. The staff gauges were installed to provide additional information to confirm that the wetlands in the area of Maple Meadow Brook is a recharge area. The location of the piezometers and staff gauges are presented on Plan 3, enclosed.

## 4.11 WATER LEVEL MONITORING

Following completion and development of all new monitoring wells, all existing and new wells, piezometers and staff gauges were surveyed for horizontal and vertical control by Dana F. Perkins. Water levels in the monitoring wells have been measured seven times between September 30, 1991 and April 21, 1993. Table 4.6 summarizes groundwater elevations measured over this period. Water levels in the surface water piezometers have been measured four times, July 22, 1992, September 3, 1992, January 7, 1993 and April 21, 1993. Table 4.7 summarizes the surface water piezometer elevations. Water levels at the staff gauges installed in Maple Meadow Brook were measured on April 21, 1993 and are summarized in Table 4.7.

### 4.12 DOWNHOLE ELECTROMAGNETIC LOGGING

Following well installation and development, a downhole geophysical electrical conductivity (EM) survey was conducted on selected wells to aid in defining the vertical extent of contaminants in the aquifer.

The EM survey was conducted by lowering a probe with a transmitter coil and receiver into the well. The transmitter, mounted at the top of the probe, induced an electric current into the geologic formation. This current produced a secondary electromagnetic field within the formation. The receiver, mounted at the bottom of the probe, measured the strength of the electromagnetic field induced by the transmitter coil. The strength of the electromagnetic field as recorded at the receiver is directly proportional to the ability of the geologic formation to "conduct" electricity. If contaminants were present dissolved in the groundwater, a corresponding elevated conductivity anomaly would be noted during EM logging.

Hager-Richter Geoscience Inc. of Salem, New Hampshire conducted the downhole EM logging in both August of 1992 and December 1992/January 1993. A discussion of the methods and results of the downhole EM logging is presented in Appendix G. The EM logging results are also discussed in Section 6.0.

#### 4.13 <u>TEMPERATURE LOGGING</u>

Hager-Richter Geoscience Inc. also conducted dual temperature logging in the newly installed bedrock monitoring wells. Temperature logging was used to help identify potential water bearing fractures which may exist in the bedrock wells. A discussion of methods and results of the temperature logging are presented in Appendix G. The temperature logging results are also discussed in Section 5.4.

# 4.14 QUALITATIVE BIOTA SURVEY/WETLANDS DELINEATION

Olin retained the firm Wetlands Preservation, Inc., of Georgetown, Massachusetts to conduct a detailed evaluation of the location and characteristics of the various upland and wetland habitat areas on and immediately adjacent to the Facility. The evaluation is documented in the report entitled "Site Habitat Characterization, Olin Chemical Facility, 51 Eames Street, Wilmington, Massachusetts" dated March 1993 and is presented as Appendix H. The report presents an upland habitat and wetland habitat evaluation and wildlife utilization.

## 4.15 <u>CSA CHEMICAL SAMPLE COLLECTION</u>

# 4.15.1 Groundwater Sampling

An initial set of groundwater samples was collected from all existing and new groundwater (GW) and sulphate landfill (SL) monitoring wells. The wells were sampled in August of 1991 by ABB personnel and were analyzed for groundwater indicator parameters ammonia, chromium, sulphate and chloride. Subsequent to this, between the period of January 1992 and May 1992, as each new well nest was completed, the wells were developed and initially sampled by CRA personnel for groundwater indicator parameter analysis. Table 4.8 summarizes when each well was sampled for the indicator parameter analysis. Subsequent to May 1992, all new wells were sampled as part of the Site Specific Parameter List (SSPL) groundwater sampling events which included indicator parameter analysis.

In December 1991, a set of groundwater samples were collected by CRA personnel from eleven selected monitoring well locations. The wells were selected based on historic and inorganic analytical data and observations made during drilling of new wells. These wells were sampled and analyzed for the full list of Target Compound List/Target Analyte List

(TCL/TAL) compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate. Table 4.9 summarizes the eleven wells sampled in December 1991.

Based on a review of the data from the eleven wells sampled in December 1991, a Site Specific Parameter List (SSPL) was developed for future groundwater, surface water and sediment sampling and analysis. The SSPL included the above parameter list except for PCBs.

Subsequent to the development of the SSPL, two rounds of groundwater samples were collected from all new monitoring wells and selected existing monitoring wells. Prior to sample collection, all monitoring wells were first purged in accordance with the protocols in Appendix H of the CSA Work Plan. All samples were analyzed for the SSPL compounds and selected samples were also analyzed for hexavalent chromium and specific gravity. The two rounds of samples were collected in August of 1992 and October/November of 1992. Wells installed after the October/November 1992 sampling event were sampled after development and are considered part of the second round sampling event. Tables 4.10 and 4.11 summarize the wells sampled during each round, respectively. Plan 3, enclosed, presents all monitoring well locations.

A peristaltic pump was used for the collection of all samples except the volatile parameter group. Volatiles were collected using a bottom filling stainless steel/teflon bailer attached to new nylon rope. Prior to use in any monitoring well, the sampling program equipment was precleaned as described in Appendix H of the CSA Work Plan. New nylon rope and dedicated teflon tubing were used at each well location.

In the event that the groundwater was still turbid following purging, appropriate sampling techniques (i.e. low pumping rate) were implemented to collect sediment-free samples or samples that were as sediment-free as possible. In the event that a well was purged dry, sample

collection commenced on the day of purging when the water level recovered to the static water level.

Filtration of water samples (0.45-micron filter, millipore aseptic unit or equivalent) in which analyses for TAL parameters was to be performed was undertaken for all monitoring well samples prior to preservation.

# 4.15.2 Surface Water Sampling

Two rounds of surface water samples were initially collected by CRA personnel from locations along the surface drainage ditches. These locations provided samples from upstream, adjacent, on and downstream of the Facility from the West, South and East Ditches. Surface water samples were collected and analyzed for the same parameters as the groundwater samples (SSPL compounds). Selected samples were also analyzed for hexavalent chromium. Round 1 surface water samples were collected in August/September 1992 and Round 2 surface water samples were collected in December 1992, subsequent to completing each groundwater sampling event. After review of both rounds of surface data, water samples were collected in the East Ditch further upstream and downstream of the Facility. These samples were collected in March/April 1993, and are considered part of the Second Round Sampling event. Tables 4.12 and 4.13 summarize the surface water samples collected during each round, respectively. Plan 7, enclosed, shows all surface water sample locations.

Surface water samples were collected in accordance with the protocols presented in Appendix H of the CSA Work Plan.

# 4.15.3 Sediment Sampling

Similar to surface water sampling, two rounds of sediment samples were initially collected by CRA personnel from locations along the surface drainage ditches. These locations provided samples from upstream, adjacent, on and downstream of the Facility from the West, South and East Ditches. Sediment samples were collected concurrent with surface water samples. Tables 4.14 and 4.15 summarize the sediment samples collected during each round, respectively. Plan 7, enclosed, shows all sediment sample locations.

A stainless steel spoon was used to reach the base of the ditch sediments. A composite sample was collected from each distinct layer of sediment encountered at each sampling location and analyzed for the same parameters as the groundwater samples (SSPL compounds). Selected samples were also analyzed for hexavalent chromium.

Sediment sampling was conducted according to the protocols presented in Appendix H of the CSA Work Plan.

# 4.15.4 Subsurface Soil Sampling

# 4.15.4.1 Subsurface Soil Sampling - Physical Characteristics

During borehole drilling for the new monitoring wells, continuous split spoon overburden samples were collected to the completed depth. Where a shallow well was installed in association with a deep well, split spoon sampling was only undertaken at the deep well location. All soil samples were described and classified according to the Unified Soil Classification System (USCS). All soil samples were retained for geologic record and are currently stored at the Facility.

# 4.15.4.2 Subsurface Soil Sampling - Chemical Characteristics

In order to characterize the soils of known and potential source areas (i.e. SWMUs), a total of 40 investigative boreholes were completed at the Facility, by Soil Exploration, under the supervision of CRA personnel, in June 1991 and February 1992.

The boreholes were completed to the top of the water table using hollow-stem augers (4 1/4-inch inside diameter, nominal 8-inch outside diameter). After completion each borehole was backfilled to ground surface with cement/bentonite grout.

In 36 of the boreholes, continuous split spoon soil samples were collected during augering from ground surface to the top of the water table (approximately 10 feet deep). A minimum of one discrete soil sample for chemical analyses was selected from each borehole location. Samples were selected based on field screening with an HNu immediately upon opening of the split spoon, visible evidence of contamination, and grain size of recovered materials. One soil sample from each borehole was analyzed by the laboratory for the full list of TCL/TAL compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

Three boreholes in the former black area east of Plant D (BH23, BH24, BH25) and one borehole in the area of the former Wytox Loading Area spill (BH11) were completed to obtain samples for analysis of the two areas. Historically, both areas were excavated and backfilled with clean fill. Continuous split spoon soil samples for geologic record were collected from ground surface to the base of the clean fill. Immediately below the clean fill soil samples for chemical analyses were collected. The soil samples from each of the boreholes were analyzed by the laboratory for the full list of TCL/TAL compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

One background subsurface soil sample was collected during the installation of monitoring well GW-67D, located approximately 1,400 feet west of the Facility.

Table 4.16 summarizes the subsurface soil samples collected for analysis. Plan 8, enclosed, shows the location of all the investigative soil borings completed as part of the CSA activities. Stratigraphic logs for the boreholes are provided in Appendix I.

All remaining soil cuttings at borehole locations were collected, placed in 55-gallon drums and transferred to a drum staging area at the Facility. Subsequent to receiving the subsurface soil analyses, the drummed soils were characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

# 4.15.5 Surface Soil Sampling

A surface soil sampling program was conducted by CRA personnel in July 1991, over the area of the Facility on an approximate 200-foot grid. In addition, four composite surface soil samples were collected from areas of suspected surficial contamination, one composite surface soil sample was collected for chromium speciation and one background surface soil sample was collected during the installation of monitoring well GW-67D. Soil samples were collected at all locations from zero to six inches below the ground surface. All samples were collected in accordance with the protocols presented in Appendix H of the CSA Work Plan. Table 4.17 summarizes the surface soil samples collected and Figure 4.2 shows the locations of all surface soil sample locations.

As shown on Figure 4.2, the Facility was divided into ten areas for the purpose of compositing grid samples. Samples collected from within each area were composited in the laboratory and analyzed for the full

TCL/TAL parameters plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

Three hand-auger soil samples were collected from the soil at the base of the black oily area on the south ditch bank (SWMU No. 30). The samples were composited in the laboratory and analyzed for the above list of parameters.

Three hand-auger soil samples were collected from the black area near the West Ditch (SWMU No. 27). The samples were composited in the laboratory and analyzed for the above list of parameters.

Three hand-auger samples were also collected from the area near monitoring well nest GW-55. This area were not identified in the CSA Work Plan however, at time of sampling, it exhibited signs of stressed vegetation. The samples (designated as SWMU No. 33) were composited in the laboratory and analyzed for the above list of parameters.

Four surface soil samples were also collected from the fuel oil spill area (SWMU No. 25). The samples were composited in the field and analyzed for the above list of parameters.

One background surface soil sample was collected during the installation of monitoring well GW-67D, located approximately 1,400 feet west of the Facility. The background sample was analyzed for TCL Polynuclear Aromatic Hydrocarbons (PAHs) and TAL parameters.

# 4.15.6 Air Sampling

As discussed in Section 5.2, the Facility is completely covered by either building, asphalt or good vegetative cover in all areas. Thus, the potential for particulate emissions at the Facility is extremely low. As discussed in Section 6.3, no volatile organic compounds (VOCs) were

detected in the surface soil samples and only low levels of VOCs were detected in subsurface soil samples. Thus, the potential for vapor emissions at the Facility is extremely low. Therefore, based on existing Facility conditions and on the analytical results for the surface and subsurface soil samples, air sampling and analysis was determined not to be required.

# 4.15.7 Private Well Sampling

## 4.15.7.1 Cook Avenue/Border Avenue Wells

In October 1990, ABB personnel, on behalf of Olin, sampled a total of nine private wells at residences located along Cook Avenue and Border Avenue, to the west southwest of the Facility. The wells were sampled in order to confirm that the wells had not been impacted by any Facility-related contaminants. The nine wells sampled are summarized in Table 3.2 and are located on Figure 3.3. All wells, with the exception of one well on Border Avenue, are completed in the bedrock.

The samples were collected by ABB in accordance with the protocols presented in Appendix E of the CSA Work Plan.

All samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of analytical reports are provided in Appendix E of the CSA Work Plan.

A review of the analytical reports presented in Appendix E of the CSA Work Plan indicates that the private well water samples from the Cook and Border Avenue residences were below all acceptable Massachusetts Drinking Water Regulations and were not impacted by any Facility-related contaminants. A summary of parameters included in the Massachusetts Drinking Water Regulations is provided in Appendix E of the CSA Work Plan.

## 4.15.7.2 Main Street Wells

In September 1991, Olin sampled a total of five private wells at residences located to the west of the Facility along Main Street. The wells were sampled in order to determine if the wells had been impacted by any Facility-related contaminants. The five wells sampled are summarized in Table 3.2 and are located on Figure 3.3. As shown in Table 3.2, the five wells are all completed in the shallow overburden.

The samples were collected by Olin in accordance with the protocols presented in Appendix J.

All samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of the analytical reports are provided in Appendix J.

A review of the analytical reports presented in Appendix J indicates that the private well water samples from the Main Street residences were below all acceptable Massachusetts Drinking Water Regulations, except for pH at one well location, and were not impacted by any Facility-related contaminants.

Notwithstanding this, during private well sampling along Main Street, it was determined by Olin that all residences with private wells either used bottled water or pretreated the water prior to drinking it.

# 4.15.8 Town Well Sampling

On September 3, 1992, CRA and Coast-to-Coast Analytical Services, Inc. (formerly ABB) personnel collected samples from the Town of

Wilmington wells located to the west of the Facility. Groundwater samples were collected from the following five locations:

- Town Park Well;
- Butters Row Well #2 (in chamber);
- Butters Row Treatment Plant (after treatment);
- Chestnut Street Well #1 (in building); and
- Chestnut Street Well #1A (in chamber).

All samples were collected directly from sample ports.

A sample was later collected at Butters Row Well #1 (inside building) on September 10, 1993 when a broken shaft that had caused the well to be shut down during sampling of the above referenced wells was replaced.

All groundwater samples were submitted to the laboratory for analyses of the full TCL/TAL parameters plus hexavalent chromium, ammonia, NH<sub>3</sub>, NO<sub>3</sub>, TKN, cyanide, EDB, DBCP, chloride, sulphate, F, NO<sub>2</sub>, TDS and pH. Field duplicate samples were collected at the Butters Row Well #2 and at the Chestnut Street #1 Well. Table 4.18 presents a summary of detected parameters in the Town of Wilmington well samples.

The organic substances detected before and after treatment were below the maximum concentration standards for drinking water established by the Federal Government.

The inorganic substances detected before treatment meet maximum concentration standards for drinking water established by the Federal Government except for iron, manganese and sodium. After treatment, the only exception was sodium which was above the State of Massachusetts standard.

### 5.0 <u>SITE CONDITIONS</u>

## 5.1 GENERAL

This section provides a detailed overview of the Site conditions based on CSA field activities as well as previous investigations completed prior to the CSA. This overview includes a discussion of:

- 1. topography;
- 2. geology;
- 3. groundwater hydrology;
- 4. surface water hydrology; and
- 5. buried materials.

For purposes of clarification, "Site" refers to the Facility grounds and surrounding region studied as part of the CSA, and "Facility" refers to that portion of the Site which lies within the property boundary.

## 5.2 <u>SITE TOPOGRAPHY</u>

The Facility is generally flat, sloping gently from north and south toward the center of the Facility. A low ridge runs along the south edge of the Facility, part of which is incorporated within the Sulphate Landfill. Trending in an east west direction through the center of the Facility, is a low lying area which is dissected by surface water drainage ditches. A small man made pond (approximately 1/2 acre in size) lies in the east central portion of the Facility. Shallow ditches run along the east and northwest sides of the Facility.

The northern 1/4 of the Facility is generally building or pavement covered. Between this area and the central low lying area is a grass covered area where the former lined lagoons had been previously located. A detailed discussion of Facility's vegetative cover, hydrology, soils and wildlife

use is presented in Appendix H in the report entitled "Site Habitat Characterization, Olin Chemical Facility, 51 Eames Street, Wilmington, Massachusetts, March 1993" prepared by Wetlands Preservation, Inc.

The area to the immediate west of the Facility is generally flat between the Site and Highway 38 (Main Street). Land use in this area is commercial and industrial with pavement and building development covering a large portion of the area. West of Highway 38, the land slopes gradually towards the west into a large wetland complex. Maple Meadow Brook, a tributary of the Ipswich River, begins in and flows north across this wetland.

The area east and south of the Facility is generally flat with the exception of the former Woburn Town Dump, which is located immediately south of the Facility.

# 5.3 SITE GEOLOGY

#### 5.3.1 General

Several previous studies have described Facility geologic conditions much of which is supported by CSA activities. The geologic units identified during the CSA include in descending order of age:

- l. glacial outwash;
- 2. glacial ice contact deposits;
- 3. glacial till; and
- 4. bedrock (fine grained sedimentary gneiss).

Each geologic unit is described in the following subsection and includes a description of each unit's depositional history and geometric relationships. Geologic cross-sections A-A' through F-F', presented on Figures 5.1 through 5.6, illustrate the stratigraphy of the Facility. Plan 9,

enclosed, illustrates the geologic cross-section locations. The Facility stratigraphy is consistent with the regional geology as discussed in Section 3.2 and is further described below.

#### 5.3.2 Outwash

Glacial outwash was observed as the uppermost geologic unit over much of the eastern portion of the Facility and was also observed on the far western portion of the Facility. This unit is a stratified, fine to medium grained, moderately sorted, sand deposit containing scattered lenses of coarse sand and gravel. Unit thickness ranges from a few feet in well GW-47 to as much as 40 feet in well GW-48D along the east side of the Facility.

# 5.3.3 <u>Ice Contact Deposits</u>

Ice contact deposits occur as the upper most unit on the western side of the Facility and extend to the west into the large wetland underlying Maple Meadow Brook. This unit is a crudely stratified, poor to moderately sorted sand and gravel deposit. Boulders are common in the upper ten feet of the unit. Coarse sand and fine to medium gravel dominate the unit. Thickness of the ice contact deposits varies from a few feet on the Facility in well GW-54D to 70 feet in well GW-62D off the western side of the Facility near the Maple Meadow Brook wetland.

#### 5.3.4 Glacial Till

Glacial till was encountered in boreholes mostly to the west of the Facility and was characteristically dense. The till consists of poorly sorted sand through boulder sized material with a minor component of silt and clay. The till was difficult to distinguish from the ice contact deposits

because of the similar lack of sorting. The till was absent or only a few feet thick over most of the Site.

## 5.3.5 Bedrock

A fine-grained gneiss bedrock is also found at the surface and underlying the Site. Bedrock outcrops occur to the southwest of the Facility in the vicinity of Cook Avenue; on the southern portion of the Facility, near the Sulphate Landfill; southwest of monitoring well nest GW-19; south of monitoring well nest GW-51; and to the northwest of the Facility, in the vicinity of Janis Research. A general bedrock high trends across the Facility from southwest to northeast.

Based on outcrop and drill core observations, the gneiss is moderately to weakly fractured/jointed in its extreme upper portions.

Joint and fracture orientation measurements were acquired from several bedrock outcrop localities at the Site. Table 5.1 presents these measurements. These data show a strong consistency in joint/fracture orientation trending in a north-northeast direction. Joint/fracture planes also show a consistency in dip angle to the north varying from approximately 40 to nearly 90 degrees. Jointing and fracturing directional strikes tended to be consistent with the strike of relict bedding observed in the gneiss. Joint and fracture frequency diminishes with depth from the bedrock surface as few open fractures and or joints were observed in drill core beyond 10 feet below the top of the bedrock surface (see Appendix E for stratigraphic logs).

The bedrock surface topography was contoured using drilling and seismic geophysical data. Plan 10, enclosed, illustrates the topography of the bedrock surface. Three bedrock valleys were identified during the CSA investigation: the West Bedrock Valley, the East Bedrock Valley, and the Southwest Bedrock Valley. A description of each of these valleys is presented below and each valley is identified on Plan 10, enclosed.

# West Bedrock Valley

The West Bedrock Valley begins just under the central portion of the Facility, and extends to the west northwest. At the Facility boundary, the valley lies at an elevation approximately 40 feet AMSL. The valley widens as it leaves the Facility boundary and eventually connects with a large bedrock valley which extends beneath the Maple Meadow Brook wetland. This valley in turn connects into the regionally extensive Ipswich River bedrock valley. The valley bottom slopes to the west and flattens out in the area just to the west of Highway 38 (Main Street). The approximate elevation of the valley at this location is 20 feet AMSL. Based on monitoring well installations, the lowest elevation of bedrock encountered was at an elevation of -13 feet AMSL at monitoring well location GW-65D.

# East Bedrock Valley

The East Bedrock Valley begins in the central area of the Facility, and extends off Site to the east and south. It appears that the West and East Bedrock Valleys are connected by a high point located near the center of the Facility beneath the area of the unlined pits and Lake Poly. The East Bedrock Valley exits the Facility with a bedrock surface elevation of 40 feet AMSL.

Two former studies which characterize geologic conditions to the east and south of the Facility indicate that this bedrock valley turns to the south just east of the Facility, and joins in with the regionally extensive Aberjona River bedrock valley (Ecology and Environment 1980, Roux and Associates 1983).

# Southwest Bedrock Valley

A third bedrock valley was characterized to the immediate southwest of the Wilmington Facility which begins just to the west of the

Sulphate Landfill and trends in a south to southwest direction. Well GW-40D, situated immediately southwest of the Sulphate Landfill, is located in the center of the Southwest Bedrock Valley. The bedrock at this location exhibits an elevation of 47 feet AMSL. Further to the southwest, at well GW-75D, the bedrock exhibits an elevation of 40.4 feet AMSL. Work completed by Ecology and Environment 1980, indicates that this valley extends to the south and joins the Aberjona River bedrock valley system.

# 5.3.6 Geologic Summary

Prior to the deposition of the glacial deposits, the bedrock surface was eroded into its current configuration by pre-glacial fluvial processes and also later by the glacial ice. The glacial till unit was the first unconsolidated unit deposited while the ice covered the landscape. The till was typically thin over most of the area and later was eroded and modified by glacial meltwater as the glacier margin retreated.

During glacial retreat, large volumes of meltwater and sediment were generated at the ice margin resulting in the deposition of a thick wedge of ice contact deposits. These deposits filled in many of the low depressions and bedrock valleys. As the ice margin further retreated meltwater streams deposited finer grained outwash on top of and interfingered with the ice contact deposits. The outwash further filled in low areas which were not completely filled by the ice contact deposits.

## 5.4 <u>SITE HYDROGEOLOGY</u>

#### 5.4.1 General

The following subsections discuss the Site hydrogeologic conditions including a discussion of the hydrostratigraphic units

(Section 5.4.2), groundwater flow (Section 5.4.3) and an overview (Section 5.4.4).

# 5.4.2 Hydrostratigraphic Units

# 5.4.2.1 Glacial Deposits

The glacial ice contact deposits and outwash function as the single, principal hydrostratigraphic unit in the Site area. These sand and gravel deposits extend in all directions from the Facility and are connected into the region's major aquifer systems. The uppermost fractured portion of the bedrock surface beneath the Site is considered a part of this flow system. Below the upper fractured bedrock minor groundwater is transmitted along small fractures and joints.

The geometry of the sand and gravel aquifer is controlled by the configuration of the underlying bedrock topography. The aquifer is thin or absent where bedrock is at or near the surface, and is thickest in the bedrock valleys which dissect the Site area.

Beneath the Facility the sand and gravel aquifer is thickest in the east and west bedrock valleys and thins to the north and south. Outwash predominates as the major unit on the eastern portion of the Facility, and correspondingly, hydraulic conductivities tend to be relatively lower. In the East Bedrock Valley, ice contact deposits lie at depth below the outwash unit. On the western side of the Facility and to the west of the Facility into the Maple Meadow Brook wetland, ice contact deposits dominate the sand and gravel aquifer and correspondingly, hydraulic conductivities tend to be higher. The aquifer in this area becomes appreciably larger in volume in the region of the West Bedrock Valley. Drilling conducted on the west and north sides of the Maple Meadow Brook wetland indicate that outwash overlays and interfingers with the ice contact deposits.

Hydraulic conductivities values for the sand and gravel aquifer were calculated from CSA hydraulic testing and also were obtained from two references which characterized regional area groundwater conditions (IEP 1990 and USGS 1694). The CSA data are presented in Table 4.5 and the regional reference are discussed in Section 3.3.1. In general, hydraulic conductivities calculated for the glacial fluvial deposits fall in a range of  $1 \times 10^{-2}$  cm/sec to  $1 \times 10^{-4}$  cm/sec.

#### 5.4.2.2 Bedrock

Four bedrock monitoring wells were installed as part of the CSA field activities. Bedrock core was obtained and examined during well construction to assess type and frequency of joints and fractures in the rock. In general, joint and fracture frequency diminishes considerably beyond ten feet of the bedrock surface. When pumped at low rates (1 to 3 gpm) all four bedrock monitoring wells drew down to a point of becoming nearly dry. Based on results of hydraulic conductivity testing, the hydraulic conductivity of the bedrock is estimated to be very low. Temperature logging conducted on bedrock wells indicated no apparent significant zones of groundwater contribution from fractures in the bedrock.

Since joint and fracture frequency diminishes at depth, and wells yielded low volumes of water, bedrock is not considered a significant source for groundwater in the region. Sufficient water, however, may be obtained for domestic purposes if wells cross cut enough joints and fractures (i.e. are drilled extremely deep). Because groundwater is available over a widespread part of the area from the sand and gravel aquifer, few wells tap the bedrock water. Bedrock supply wells are found only in places where both municipal water is not available, and the sand and gravel aquifer is thin or absent (e.g. Cook Avenue residences).

# 5.4.3 Groundwater Flow System

# 5.4.3.1 General

The CSA study area encompasses portions of two hydrologic basins with the divide located west and north of the Facility. The divide was characterized and supported by data obtained during the CSA and has also been identified and characterized in other regional studies (IEP 1990 and USGS 1694) and is illustrated as both a surface water and groundwater divide or hydraulic boundary. Plans 11 through 14, enclosed, present the groundwater elevations from two water level monitoring events, as measured in the monitoring wells assuming insignificant variation in the density of water in the wells. Also presented are the contours for shallow and deep groundwater from the two water level monitoring events and the location of the hydraulic boundary. In the area of the groundwater divide, horizontal hydraulic gradients are very low, with little difference in hydraulic head apparent. This is reflective of the relatively high hydraulic conductivities associated with coarse grained ice contact deposits and may be influenced by the groundwater withdrawal of Altron.

Because the gradients are so low, the exact position for the groundwater divide cannot be discerned, however, a zone which represents the region of the divide has been illustrated on the groundwater elevation plans (Plans 11 through 14). For the purposes of this report, the groundwater flow system (i.e. flow directions and flow rates) will be broken down into two areas:

- the area occupying the majority of the Facility and that area west of the Facility but east of the hydraulic boundary which is located within the Aberjona River hydrologic basin; and
- the area west of the hydraulic boundary which is located within the Ipswich River hydrologic basin.

# 5.4.3.2 East of Hydraulic Boundary

#### Groundwater Flow Patterns

In the area east of the hydraulic boundary, the general groundwater flow direction is from northwest to southeast across the main part of the Facility. In all water level monitoring events, a zone of radial flow centers on the north end of the Facility. This zone appears to indicate that a certain amount of aquifer recharge is occurring in this area. However, it should be noted that the aquifer is relatively thin in this area, and appears, based on the steepness of the horizontal hydraulic gradients, to be a zone of lower hydraulic conductivity.

On the northeast side of the Facility, groundwater is currently being pumped by Olin as discussed in Section 2.2. The pumping in this area influences the groundwater flow as seen by the steep gradients along the east side of the Facility.

Towards the center of the Facility, groundwater flows in general towards the south ditch, and on the west contours wrap around the ditch showing groundwater flow towards and discharging into the ditch. Visible groundwater discharge has been observed in the south ditch on the west side of the Facility over the entire 1 1/2-year course of the CSA investigation.

Groundwater contours in the vicinity of the NPDES discharge into the west ditch, show that a small amount of "mounding" may be influencing groundwater flow in this area.

Along the east side of the Facility groundwater flows towards the east ditch with a certain amount of discharge occurring based on observations of seeps by former Site investigators. Flow in the ditch also increases, generally, from north to south along the Facility boundary.

To the southwest of the Facility, a small groundwater divide is present. Here, groundwater flows from the extreme southwest portion of the Facility to the south.

West of the Facility boundary and towards the hydraulic boundary, the groundwater flows in a southeasterly direction towards the Facility and the south ditch. In this area, horizontal gradients are extremely flat reflecting the relatively high hydraulic conductivity associated with the coarse ice contact deposits which dominate the aquifer in this area.

# Horizontal Hydraulic Gradients

The horizontal hydraulic gradients for the shallow and deep groundwater flow contours are essentially the same. Therefore, the horizontal hydraulic gradients discussed herein apply to flow across the entire aquifer.

At the northern end of the Facility, the horizontal hydraulic gradient is approximately 0.013 feet per feet and on the west side of the Facility is approximately 0.003 feet per feet. Extremely flat horizontal gradients (0.0003 feet per feet) were measured in the area between the hydraulic boundary and the Facility. In the center of the Facility, the horizontal hydraulic gradient on the east side is approximately 0.01 feet per feet. The steeper gradient on the east side of the divide is attributed to the pumping at Plant B and to lower hydraulic conductivity in this area.

# Groundwater Flow Velocity

An estimate of the groundwater velocity in the glacial fluvial aquifer may be determined using the modified Darcy's Equation:

V = ki/n

where:

V = horizontal groundwater velocity

k = horizontal hydraulic conductivity

i = horizontal hydraulic gradient

n = effective porosity

As presented in Section 4.9, the horizontal hydraulic conductivity for the monitored intervals ranged from  $7.7 \times 10^{-2}$  to  $9.7 \times 10^{-4}$  cm/sec with a geometric mean of  $7.9 \times 10^{-3}$  cm/sec. An effective porosity of 0.25 may be assumed to be representative of the glacial fluvial deposits. Using the horizontal hydraulic conductivity geometric mean and a porosity of 0.25, the horizontal groundwater velocity was calculated to range from approximately 100 feet to 325 feet per year on the Facility. In the area west of the Facility where the horizontal gradients are low (0.0003 feet per feet), the groundwater flow velocity was calculated at 10 feet per year. The calculated flow velocities are estimates and may vary by an order of magnitude.

# 5.4.3.3 West of Hydraulic Boundary

Groundwater Flow Patterns

West of the hydraulic boundary, groundwater flow is directed to the west into the main portion of the regional aquifer. The Town of Wilmington pumping stations at Chestnut Street, Butters Row and the Town Park, function as discharge points for a portion of the groundwater in this area.

Maple Meadow Brook functions to some extent as a groundwater discharge point for at least a portion of the groundwater in the basin based on the observed baseflow emanating from the wetland. The

recharge area for this system is largely occupied by the wetland itself which dominates this portion of the basin.

# Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were calculated west of the hydraulic boundary and ranged from 0.013 to 0.0003 feet per feet. The flat gradients were observed where the coarse ice contact deposits form the major hydrostratigraphic unit.

# Groundwater Flow Velocity

Again, using the modified Darcy's Equation (see Section 5.4.3.2) an estimate of the groundwater velocity can be made. Using the horizontal hydraulic conductivity geometric mean and porosity values discussed in Section 5.4.3.2 and the horizontal gradients discussed above, the groundwater flow velocity west of the divide was calculated to range from 10 to 425 feet per year. These velocities are estimates and may vary by an order of magnitude.

## 5.5 SITE SURFACE WATER HYDROLOGY

#### 5.5.1 General

The Facility contains a network of ditches which bound and run through the center of the Facility. These ditches have been labeled based on their location at the Facility and are described below. Plan 7, enclosed, shows the locations of these ditches.

# 5.5.2 West Ditch

The West Ditch begins along the northwest side of the Facility and drains to the south. The West Ditch functions as the point of discharge for Olin's NPDES outfall and enters the South Ditch on the west center side of the Facility. A second branch of the West Ditch begins in a network of collection trenches just west of the Facility boundary, parallels then joins the West Ditch just east of the Facility boundary. Base flow in the West Ditch appears to be minor.

#### 5.5.3 South Ditch

The South Ditch begins at the Facility boundary along the west side. The South Ditch bisects the Facility, flows east across the center of the Facility and discharges off of the Facility into the East Ditch. A branch of the South Ditch parallels and then joins the South Ditch at the eastern Facility boundary. A constant base flow (groundwater discharge) is observed in the South Ditch network. Seeps are observed along the western portion of the ditch network. The branch of the South Ditch which enters from the south contains no base flow and functions principally as a surface water runoff feature.

#### 5.5.4 East Ditch

The East Ditch begins to the north of the Facility, and flows south along the entire east side of the Facility paralleling the Boston and Maine Rail Line. Rainfall runs off the Facility by sheetflow runoff into surrounding wetlands which eventually empty into the East Ditch. South of the Facility, the East Ditch enters and exits a series of culverts eventually flowing into Halls Brook, a tributary of the Aberjona River.

A constant baseflow (groundwater discharge) was observed in the East Ditch over the 11/2-year period in which the CSA was conducted. The East Ditch also receives surface water runoff for a significant portion of the surrounding area.

### 5.6 SUMMARY OF BURIED WASTES

#### 5.6.1 General

Twenty-nine test pit excavations in a total of 13 areas were conducted at the Facility to investigate magnetic anomalies identified on the Facility, as discussed in Section 4.4. Nine test pit excavations in a total of three areas were also conducted in the area of the warehouses at the Facility to investigate the potential for buried waste in this area, as discussed in Section 4.6. Waste was not encountered in ten of the 13 test pit areas excavated across the Facility and was not encountered in any of the three test pit areas excavated beneath the warehouses at the Facility. In some of the test pit areas, miscellaneous non-hazardous metal objects (i.e. fence posts) were excavated over identified magnetic anomalies. In other areas where magnetic anomalies were detected, shallow bedrock or large buried boulders were encountered. Magnetic minerals in the rock may have caused the magnetic anomalies at these locations.

Drummed waste, miscellaneous waste, and contaminated soil were encountered in three of the test pits at the locations shown on Plan 5, enclosed. The area where test pits 6, 7 and 8 were excavated, contained the most abundant buried drums. The area where test pit areas 18, 19 and 20 were excavated, contained a few miscellaneous drum parts, and contaminated soil. The area where test pit 21 was excavated, contained a mixture of scattered buried drums and miscellaneous debris. The following presents a brief description of areas where buried drums, drum parts and contaminated soil were encountered.

### 5.6.2 Encountered Waste Description

Test Pits 6, 7, 8

Drums were encountered throughout most of the area encompassing test pits 6, 7 and 8. Drums were observed up to three deep in a portion of the area. Almost all drums were deteriorated and were of very poor integrity. The drums contained miscellaneous compounds tentatively identified by the former Facility manager as Opex, Kempore and phenolic resins. In addition, a blue solid substance and a gray greasy viscous substance were also observed. Other miscellaneous wastes such as hard phenolic resins, jars of unknown compounds, unidentified loose compounds and tentatively Opex and Kempore were also encountered in these test pits.

Test Pits 18, 19, 20

A few crushed drums and drum parts were encountered in this area. Miscellaneous rubbish was also encountered. Soil contamination was visually evident and also indicated by an OVA. The odor was tentatively identified by former Facility personnel as diphenylamine or "Plant B odor". Most wastes encountered, however, were identified as rubbish.

Test Pit 21

Test pit 21 was excavated in an area not identified by a magnetic anomaly. Based on information provided by the former Facility manager, it was determined that waste may be buried in that area. Excavation of test pit 21 confirmed that buried drums, laboratory bottles and miscellaneous wastes identified as a blue substance, a gray viscous substance, rubbish and tentatively Opex and Kempore were buried in that area. Scattered drums which were encountered were very deteriorated and/or

crushed. Drums contained a blue substance, a gray substance, phenolic resins, and tentatively Kempore.

# 5.6.3 Summary

Buried wastes were encountered in three of the 22 areas that were identified to potentially contain buried wastes. These areas are identified on Plan 5, enclosed. Test pit areas 6, 7 and 8 contained extensive buried drums and miscellaneous wastes. Test pits 18, 19, 20 contained little drum waste but did contain contaminated soil and rubbish. Test pit area 21 contained scattered buried drums and miscellaneous wastes.

#### 6.0 <u>SITE CHARACTERIZATION</u>

Extensive sampling of surface and subsurface soils, groundwater, surface water and sediments was conducted during the CSA Phase II field activities. The objective of the CSA Phase II investigation was to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. This section, therefore, provides a discussion of the results of the CSA Phase II sampling program and a characterization of the materials released at or from the Facility. This section also discusses the aspects of surface water and groundwater hydrology affecting the distribution and transport of the Facility-related compounds. As discussed in Section 1.0, ABB has prepared the CSA Phase II Risk Assessment Report which characterizes and evaluates the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. The CSA Phase II Risk Assessment Report combined with this CSA Phase II Field Investigation Report provide the basis to develop remedial response alternatives, as required under 310 CRM 40.546.

### 6.1 CSA DATA BASE

The CSA Phase II field investigation data base consists of physical information described and documented in Sections 2.0 through 5.0 and the analytical results of samples collected from the various media.

The samples collected during the CSA Phase II field investigation activities are discussed in Section 4.15 and Table 4.1 provides a chronological summary of the dates when samples were collected. All samples collected for chemical analyses were analyzed by ast-to-Coast Analytical Services, Inc., (formerly ABB) of Westbrook, Maine certified by Massachusetts D.E.P. ID number ME019 and meeting the Minimum Standards for Analytical Data for Remedial Response Actions under

MGLc.21.E, Policy #WSC-300-89. These samples include, but are not limited to:

- i) eight test pit soil/drum samples analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs), TCL Semi-Volatile Organic Compounds (SVOCs), TCL Pesticides/PCBs, Target Analyte List (TAL) parameters, 2,4,4-Trimethyl-1-Pentene (244TM1P), 2,4,4-Trimethyl-2-Pentene (244TM2P), ammonia, chloride and sulphate (see Table 4.2);
- ii) ten composite surface soil samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17);
- iii) one composite surface soil sample analyzed for total chromium and hexavalent chromium;
- iv) four composite hand auger shallow subsurface soil samples (upper two feet) analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17);
- v) 40 subsurface soil samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.16);
- vi) one background surface soil sample and one background subsurface soil sample from the same borehole location (BH-41) analyzed for TCL Polynuclear Aromatic Hydrocarbons (PAHs) and TAL parameters;
- vii) 62 groundwater samples analyzed for indicator parameters ammonia, chromium, chloride and sulphate (see Table 4.8);

- viii) 11 groundwater samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244 TM2P, ammonia, chloride and sulphate plus an additional groundwater sample from one location for PCB analyses (see Table 4.9);
- ix) two rounds of groundwater samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 114 samples and second round consisted of 136 samples including QA/QC requirements), during the first round, 19 samples for specific gravity analyses and 11 samples for hexavalent chromium, and during the second round, 18 samples for specific gravity analyses and 11 samples for hexavalent chromium were also collected (see Tables 4.10 and 4.11);
- x) two rounds of surface water samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 22 samples and second round consisted of 36 samples including QA/QC requirements), during the first round 2 samples for hexavalent chromium analysis and during the second round 6 samples for hexavalent chromium analysis were also collected (see Tables 4.12 and 4.13); and
- two rounds of sediment samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 25 samples and second round consisted of 35 samples including QA/QC requirements), during the first round, 2 samples for hexavalent chromium analysis and during the second round 8 samples for hexavalent chromium analyses were also collected (see Tables \* 14 and 4.15).

Analyses of the foregoing samples were performed by Coast-to-Coast using the following methods:

| Matrix   | Parameter  | Analytical<br>Method (1)                         | Method<br>Reference |
|--|--|--|---------------------|
| Groundwater<br>Surface Water/<br>Soil/Sediment/<br>Drummed Waste | TCL-VOCs<br>TCL-BNAs<br>TCL-Pesticides/PCBs<br>TAL-Metals<br>Cyanide | 8240<br>8270<br>8080<br>6010/7000 series<br>9010 | 1<br>1<br>1<br>1    |
|  | General Chemistry<br>Parameters                                      |  |                     |
|  | Sulphate<br>Chloride<br>Ammonia                                      | 9038<br>9250/9251<br>350.2 (modified)            | 1<br>1<br>2         |

#### References:

- (1) Test Methods for Evaluating Solid Waste, USEPA SW-846, 3rd Edition, November 1986.
- (2) "Methods for Chemical Analysis of Water and Wastes", EPA-600/04-79-020, Revised, March 1983.

Complete analytical data summaries are presented in Appendix L. Appendix L presents summary tables of detected parameters in each media, summary tables of frequency of detections, maximum and minimum detected concentrations and average detected concentrations, and complete summary tables (including detected and non-detected parameters) for each media.

The laboratory reports were assessed and validated by CRA's quality assurance/quality control (QA/QC) officer based upon a review of standard quality control criteria established by the QAPP (Appendix F of CSA Work Plan). The data assessment and validation reports for all CSA Phase II Field Investigation activities data are presented in Appendix M.

On the basis of the formal data validation identified in the foregoing discussion, all data presented on the tables have been qualified as appropriate.

#### 6.2 CSA DATA PRESENTATION

As discussed above, Appendix L presents complete summary tables for analytical data generated during the course of the CSA Phase II Field Investigation. Based upon a review of the analytical data and due to the size of the data base it was decided that for each media (i.e. surface soil, subsurface soil, groundwater, surface water and sediment) the following data would be presented on plans for each media:

- Total Halogenated Volatile Organic Compounds (HVOC);
- Total of 244TM1P and 244TM2P (Pentenes);
- Total Benzene, Toluene, Ethylbenzene & Xylene (BTEX);
- Total Polynuclear Aromatic Hydrocarbons (PAHs);
- Total Phthalate Isomers (PHTH);
- Total Phenolic Compounds (PHE);
- N-Nitrosodiphenylamine (N-NDPA);
- Ammonia;
- Chloride:
- Chromium; and
- Sulphate.

For surface water and sediments, aluminum is also presented on each respective plan.

## 6.3 <u>DRUM WASTE CHEMISTRY</u>

### 6.3.1 General

As discussed in Section 5.6, drummed waste, miscellaneous waste, and visibly contaminated soils were encountered in three of the 16 test pit areas excavated at the Facility. The location of these areas are shown on Plan 5, enclosed. The area where test pits 6, 7 and 8 were excavated, contained the most abundant buried drums. The area where test

pits 18, 19 and 20 were excavated, contained a few miscellaneous drum parts, and contaminated soil. The area where test pit 21 was excavated, contained a mixture of scattered buried drums and miscellaneous debris. Section 5.6.2 presents a more detailed description of the wastes encountered in the test pit excavations. Section 4.4 discusses the test pit excavation protocols, which included the collection of eight drum and/or soil samples for chemical analyses. As summarized in Section 6.1, eight test pit soil/drum samples were collected and analyzed for TCL VOCs, TCL SVOCs, TAL parameters, TCL Pesticides/PCBs, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

A summary of the drum and/or soil samples collected for chemical analyses is presented in Table 4.2. A summary of the following data is presented in Appendix L:

- Tab 7 Summary of Detected Test Pit Data;
- Tab 8 Average Detected Concentrations for Test Pit Data (includes frequency of detection); and
- Tab 17 Summary of Test Pit Data.

The following subsection presents a summary of the analytical data for the areas where buried drums, drum parts and contaminated soils were encountered.

# 6.3.2 Test Pit Characterization

### 6.3.2.1 Test Pits 6, 7, 8

Drums were encountered throughout most of the area encompassing test pits 6, 7 and 8. As summarized in Table 4.2, one drum sample was collected from test pit 6 and two drum samples plus one duplicate sample were collected from test pit 8.

A review of the VOC data presented in Appendix L, Tab 7, shows that seven volatile organic compounds (VOCs) were detected in the four drum samples. The maximum detected concentrations were 0.88 mg/kg for Toluene and 0.6 mg/kg for 2-Hexanone (MNBK). The other five VOCs were all detected at concentrations of less than 0.1 mg/kg.

**SVOCs** 

A review of the SVOC data presented in Appendix L, Tab 7, shows that two semi-volatile organic compounds (SVOCs) were detected in the four drum samples. Bis(2-ethylhexyl)phthalate (B2EHP) was detected in two samples at concentrations of 16 mg/kg and 4.4 mg/kg and N-Nitrosodiphenylamine (NNDPA) was detected in one sample at a concentration of 21,000 mg/kg. As summarized in Table 2.1, NNDPA and phthalate plasticizers were products produced at the Facility.

Pesticides/PCBs

No PCBs or pesticides were detected in the four drum samples.

Inorganics

A comparison of the inorganic data presented in Appendix L, Tab 7 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the four drum samples exhibit concentrations above background for the Site:

| Compound         | Max. Detected Conc. (mg/kg) |
|------------------|-----------------------------|
| Ammonia          | 2,100J                      |
| Calcium          | 27,000                      |
| Chloride         | 25,000J                     |
| Chromium (total) | 90                          |

### Compound

## Max. Detected Conc. (mg/kg)

| Iron      | <b>2</b> 8,000 | ) |
|-----------|----------------|---|
| Potassium | 16,000         | ) |
| Sodium    | 4,800          |   |
| Sulphate  | 5,600J         |   |

A comparison of the chromium, iron and potassium concentrations to the natural background concentration ranges of these parameters in soils for the eastern United States (see Table 6.1) indicates that all three parameter concentrations are within the natural background concentration ranges.

### 6.3.2.2 Test Pits 18, 19, 20

Limited excavation revealed remnants of an undetermined number of crushed drums and drum parts and miscellaneous rubbish in the area encompassing test pits 18, 19 and 20. As summarized in Table 4.2, one soil sample was collected from test pit 19—

#### VOCs

A review of the VOC data presented in Appendix L, Tab 7, shows that four VOCs, all at concentrations less than 0.002 mg/kg were detected in the soil sample.

#### **SVOCs**

With the exception of Phenol at a concentration of 5.3J mg/kg and N-Nitrosodipropylamine (NNDNPA) at a concentration of 1.6J mg/kg, no other SVOCs were detected in the soil sample.

### Pesticides/PCBs

No PCBs or pesticides were detected in the soil sample.

### Inorganics

With the exception of Ammonia at a concentration of 490 mg/kg, no other inorganics were detected in the soil sample at concentrations above background for the Site.

#### 6.3.2.3 Test Pit 21

Scattered drums/drum parts, laboratory bottles and miscellaneous wastes were encountered in the area of test pit 21. As summarized in Table 4.2, one drum sample and one soil sample were collected from test pit 21.

VOCs

A review of the VOC data presented in Appendix L, Tab 7, shows that three VOCs were detected in the drum sample and one VOC was detected in the soil sample. With the exception of Acetone at a concentration of 0.25 mg/kg, the other VOCs were detected at concentrations less than 0.004 mg/kg.

**SVOCs** 

In the drum sample, various SVOCs were detected including chlorobenzenes (maximum detected was 1,4-Dichlorobenzene at 1.2 mg/kg), phenolic compounds (maximum detected was 4-Methylphenol at 8.8 mg/kg), phthalate isomers (maximum detected was B2EHP at 2.5 mg/kg) and NNDPA at 1.5 mg/kg. In the soil sample, B2EHP was detected at a concentration of 1,100J mg/kg.

#### Pesticides/PCBs

With the exception of Endosulfan I at 0.036J mg/kg in the soil sample, no other pesticides or PCBs were detected.

### Inorganics

A comparison of the inorganic data presented in Appendix L, Tab 7 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the two samples exhibit elevated concentrations above background for the Site:

| Compound | Concentration<br>Soil | (mg/kg)<br>Drum |
|----------|-----------------------|-----------------|
| Ammonia  | 47                    | 100             |
| Calcium  | 160,000               | 5000            |
| Iron     |                       | 40,000J         |
| Sulphate | 29,000                |                 |

The concentration for iron is, however, within its natural background concentration range in soils for the eastern United States (see Table 6.1).

# 6.3.2 <u>Test Pit Waste Summary</u>

Based on the test pit excavation program, there are three areas at the Facility which exhibited evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. During excavation of these areas, a previous plant manager tentatively identified materials within the test pits of the three areas as Opex, Kempore, and Plant B material (diphenylamine) (previous processes at the Facility, see Table 2.1).

The analytical data collected during the test pit excavations indicated that three organic compounds B2EHP, NNDPA and

NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate were the major parameters detected in the drum and/or soil samples.

The B2EHP, NNDPA and NNDNPA all exhibit high partitioning coefficients (K<sub>OC</sub>) (see Appendix K), and will strongly adsorb to organic material in soils. Therefore, they will have a low potential for partitioning to the groundwater and are virtually immobile in the soils. However, inorganic compounds ammonia, chloride and sulphate exhibit high solubilities. Ammonia is readily soluble in water (see Appendix K), and therefore, will have a high potential for partitioning to the groundwater. Chlorides and sulphates, which are normal soil constituents, exist primarily as anions in a wide range of pH. These anions are readily soluble in water although differing complexing tendencies will depend on soil chemistry such as pH and organic carbon content. The other inorganic compounds are virtually immobile in soils under normal conditions (i.e. neutral pH), but their leachability from the soil, would increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to the fate and transport of the above compounds.

# 6.4 SOIL CHEMISTRY

### 6.4.1 General

As discussed in Sections 4.15.4 and 4.15.5, extensive subsurface and surface soil sampling programs for chemical analysis were conducted as part of the CSA Phase II field activities. The surface soil sampling locations are shown on Figure 4.2. The locations where the subsurface soil samples were collected are shown on Plan 8, entered.

Summaries of subsurface soil and surface soil samples collected for chemical analyses are presented in Tables 4.16 and 4.17, respectively. A summary of the following data is presented in Appendix L:

# Surface Soils

- Tab 5 Summary of Detected Surface Soil Data;
- Tab 6 Average Detected Concentrations for Surface Soil Data; and
- Tab 16 Summary of Surface Soil Data.

## Subsurface Soils

- Tab 3 Summary of Detected Subsurface Soil Data;
- Tab 4 Average Detected Concentrations for Subsurface Soil Data; and
- Tab 15 Summary of Subsurface Soil Data.

The following subsections present a summary of the analytical data for Facility surface soils and subsurface soils.

## 6.4.2 Surface Soil Characterization

#### 6.4.2.1 General

As summarized in Section 6.1, ten composite surface soil samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17). In addition, four composite hand auger shallow subsurface soil samples (upper two feet) were collected and analyzed for TCL TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate. An additional composite hand auger shallow subsurface soil sample was collected for total chromium and hexavalent chromium analysis. One background surface soil sample was also collected and analyzed for TCL PAHs and TAL parameters.

The ten composite surface soil samples each consisted of four discrete samples which were composited by the laboratory and the four

composite shallow hand auger samples each consisted of three discrete samples which were also composited by the laboratory (see Section 4.15.5). The additional composite hand auger sample collected for total chromium and hexavalent chromium analysis consisted of two discrete samples which were composited in the field. The background surface soil sample was a discrete shallow split-spoon sample collected during the installation of well nest GW-67, located approximately 1,400 feet west of the Facility.

The following subsections present a summary of the analytical data for the ten composite surface soil samples, the four composite hand auger samples and the single chromium speciation sample

# 6.4.2.2 Surface Soil Samples - Areas 1 to 10

**VOCs** 

A review of the VOC data presented on Plan 34, enclosed, and in Appendix L, Tab 5, shows sporadic and infrequent detection of only five VOCs in the ten composite surface soil samples. Toluene (MEC6H5) was detected in four of the ten samples but all detections were at concentrations less than 0.004J mg/kg. Methylene Chloride (C2CL2), 244TM1P and 244TM2P were detected in one sample at concentrations of 0.036 mg/kg, 0.014 mg/kg and 0.005J mg/kg, respectively.

**SVOCs** 

A review of the SVOC data presented on Plan 34, enclosed, and in Appendix L, Tab 5, shows that various PAHs and phthalate isomers were detected in the ten composite ourface soil samples. The maximum concentrations of PAHs detected were Chrysene (CHRY) at 0.64J mg/kg and Benzo(b)Fluoranthene (BBFANT) at 0.56J mg/kg. Most other PAHs were detected at concentrations less than 0.2 mg/kg. A comparison of the PAHs in the surface soil samples to Site-specific background data (see

Appendix L, Tab 20) indicates that all the PAHs are above background for the Site. However, as noted in Appendix K, PAHs are ubiquitous in the environment and the levels found in the Facility surface soil samples parallel those for industrial and urban development. A comparison of the PAHs in the surface soils to typical background concentrations in rural, agricultural, and urban soils (see Table K.5, Appendix K) shows that the PAHs detected in the surface soils at the Site are well below typical urban soil concentrations and within typical agricultural soil concentrations. The prevalent phthalate isomer detected in the soils was B2EHP, which was detected in all ten surface soil samples, at concentrations ranging from 0.066J mg/kg to 89 mg/kg.

### Pesticides/PCBs

A review of the Pesticide/PCB data presented on Plan 34, enclosed, and in Appendix L, Tab 5 shows infrequent detection of the following three pesticides: 4,4'-DDD, 4,4'-DDE and 4,4'-DDT. All three were detected in Area 4 at concentrations of 0.039J mg/kg, 0.049J mg/kg and 0.68J mg/kg, respectively and only 4,4'-DDT was detected in Area 5 at a concentration of 0.061J mg/kg. Both of these areas (see Plan 34) are situated immediately adjacent to Eames Street. No PCBs were detected in any of the samples.

# Inorganics

A comparison of the inorganic data presented on Plan 34, enclosed, and in Appendix L, Tab 5 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the surface soil samples exhibit sporadic elevated concentrations above background for the Site:

# Compound

Max. Detected Conc. (mg/kg)

Ammonia Calcium Chromium (total) Sulphate 170 (all Areas) 534,000 (Area 8 only) 750 (Area 1 and 8 only) 28,000J (Area 1 and 8 only) As shown above, with the exception of ammonia present in all areas, the other three inorganic compounds exhibited elevated concentrations in Area 1 and/or Area 8 (see Plan 34).

## 6.4.2.3 Hand Auger Samples

As discussed in Section 4.15.5, a total of four composite hand auger samples of Site surface soils were collected. Three composite hand-auger samples were collected from areas exhibiting visual signs of contamination (SWMU No. 27, SWMU No. 30 and SWMU No. 33). An additional composite hand-auger sample was collected from the area of SWMU No. 25 at which earlier fuel oil spills had occurred. All samples were collected within the upper two feet of the ground surface.

Based on initial sampling results, a second composite sample was collected from the area of SWMU No. 27 for chromium speciation analyses.

VOCs

A review of the VOC data presented in Appendix L, Tab 5, shows sporadic and infrequent detection of seven VOCs in the four hand-auger samples. SWMU No. 27 along the West Ditch (see Figure 4.2) detected six VOCs which included 244TM1P (0.3J mg/kg), 244TM2P (0.039 mg/kg), Acetone (0.093J mg/kg), C2CL2 (0.047J mg/kg), Tetrachloroethene (TCLEE) (0.073J mg/kg) and MEC6H5 (0.015J mg/kg). The sample from SWMU No. 30 (South Ditch) exhibited detected concentrations of only three VOCs, at concentrations less than 0.02 mg/kg and the sample from SWMU No. 33 (near well nest GW-55) exhibited detected concentrations of two VOCs, both at concentrations of 0.001J mg/kg. The sample from SWMU No. 25 exhibited no detectable VOC concentrations.

#### **SVOCs**

A review of the SVOC data presented in Appendix L, Tab 5, shows that phthalate isomers were detected in three of the four hand-auger samples. B2EHP was detected at SWMU No. 27 at a concentration of 5,500J mg/k, at SWMU No. 33 at a concentration of 34J mg/kg and at SWMU No. 25 at a concentration of 2.2 mg/kg.

### Pesticides/PCBs

A review of the Pesticide/PCB data presented in Appendix L, Tab 5, shows that only 4,4'-DDE and Endosulfan II (BENSLF) were detected at SWMU No. 30 at concentrations of 1.7J mg/kg and 0.34J mg/kg, respectively and that Alpha-BHC (ABHC) and BENSLF were detected at SWMU No. 27 at concentrations of 0.22J mg/kg and 0.092J mg/kg, respectively. No PCBs were detected in any of the samples.

## Inorganics

A comparison of the inorganic data presented in Appendix L, Tab 5 to Site-specific background data (BH41 at GW-67 well nest) presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the hand-auger samples exhibited sporadic elevated concentrations above background for the Site:

|                  |             | Concentration (mg/kg) |             |             |
|------------------|-------------|-----------------------|-------------|-------------|
| Compound         | SWMU No. 25 | SWMU No. 27           | SWMU No. 30 | SWMU No. 33 |
| Aluminum         | سد سد       | <b>⊸</b>              |             | 59,000      |
| Ammonia          | 13          | 670J                  | 400         | 300         |
| Chromium (total) | 19          | 4,500                 | 3,600       | 5,000       |
| Iron             | <del></del> | <del>-</del> -        |             | 100,000     |
| Nickel           | 12          | ~ ~                   | <b>-</b> *  | 67          |
| Sulphate         | <del></del> | ~ -                   | 1,200J      | 2,400J      |
| Zinc             | 21          |                       | <b></b>     | 180         |

As shown above, elevated levels of ammonia and chromium are exhibited at three locations and sulphate at two locations. The

elevated levels of the other inorganics, aluminum, iron, nickel and zinc at SWMU No. 33, are all within natural background concentration ranges for metals in soils of the eastern United States (see Table 6.1).

### Chromium Speciation

Chemical speciation was conducted at SWMU No. 27 to determine the ratio of total chromium to hexavalent chromium (Cr VI) within the surface soil. A ratio of approximately six percent Cr VI to total chromium was observed.

## 6.4.2.4 Surface Soil Characterization Summary

The analytical data collected during the surface soil/hand-auger sampling program indicated that B2EHP and inorganic compounds ammonia, chromium and sulphate were the major parameters detected in the surface soils.

As discussed for test pit samples, B2EHP exhibits a high K<sub>OC</sub> value and will strongly adsorb to organic material in soils. Therefore, it has a very low potential for partitioning to the groundwater and will be virtually immobile in the soils. However, the migration of B2EHP may occur via sediment transport in surface water runoff. The inorganic compounds ammonia and sulphate exhibit high solubilities and will therefore exhibit a high potential for partitioning to groundwater and/or surface water. Chromium is considered to be virtually bound to the soils under normal conditions (i.e. neutral pH), but its leachability from the soil would increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to the fate and transport of the above compounds.

#### 6.4.3 Subsurface Soil Characterization

#### 6.4.3.1 General

As summarized in Section 6.1, 40 subsurface soil samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.16) and one background subsurface soil sample was collected and analyzed for TCL PAHs and TAL parameters. The background subsurface soil sample was collected during the installation of well nest GW-67, located approximately 1,400 feet west of the Facility.

#### 6.4.3.2 Characterization

**VOCs** 

A review of the VOC data presented on Plan 15, enclosed, and in Appendix L, Tab 3, shows that 244TM1P, 244TM2P, Toluene, 2-Butanone (MEK), 2-Hexanone (MNBK) and Acetone were detected across the Facility.

was detected in 30 of 40 samples. The concentration of 244TM1P ranged from 0.002 mg/kg to 7.0 mg/kg with an average detected concentration of approximately 0.68 mg/kg. The concentration of 244TM2P ranged from 0.001 mg/kg to 5.1 mg/kg with an average detected concentration of approximately 0.44 mg/kg. The highest levels of both 244TM1P and 244TM2P were detected in borehole locations BH9, BH11, BH15, BH17, BH23, BH25, BH26 and BH34. BH9 is located in the area of a former lagoon (SWMU No. 9). BH11 and BH15 are located adjacent to the southwest corner of the warehouse, in the vicinity SWMU No. 18 and SWMU No. 24 (see Figure 4.2). BH17 is located in the former Lake Poly area (SWMU No. 14). BH23 and BH25 are located in the area east of Plant D (SWMU No. 26). BH34 is located

in the Plant B area (SWMU No. 13 and 23) and BH26 is located in the area the former by-product HCl tank (SWMU No. 3). The data shows that 244TM1P and 244TM2P are present in subsurface soils across the Facility.

Toluene, MEK, MNBK and Acetone were detected in 24 of 40 samples, 16 of 40 samples, 12 of 40 samples and 11 of 40 samples, respectively. The detected concentrations ranged as follows:

|          | Detected Concentration (mg/kg) |         |         |  |
|----------|--------------------------------|---------|---------|--|
| Compound | Minimum                        | Maximum | Average |  |
| Toluene  | 0.0008                         | 4.8     | 0.22    |  |
| MEK      | 0.0006                         | 0.49    | 0.04    |  |
| MNBK     | 0.001                          | 3.8     | 0.34    |  |
| Acetone  | 0.016                          | 17.0    | 1.7     |  |

The maximum concentrations of MEK and Acetone were detected in the area of the former lagoons (SWMU No. 9 and 10). The maximum concentrations of Toluene and MNBK plus elevated levels of ethylbenzene (ETC6H5) at 2.3 mg/kg and Styrene at 3.3 mg/kg were detected at BH15 (SWMU No. 18).

Other VOCs detected in the soil samples were sporadic and infrequent at concentrations ranging from 0.0005 mg/kg to 0.035 mg/kg, with the exception of a single hit of methylene chloride at 2.0 mg/kg.

**SVOCs** 

A review of the SVOC data presented on Plan 15, enclosed, and in Appendix L, Tab 3, shows that phthalate isomers and N-Nitrosodiphenylamine (NNDPA) were the most prevalent SVOCs detected in the subsurface soils.

The phthalate isomers detected included B2EHP (29 out of 40 samples), Butyl Benzylphthalate (BBZP) (10 out of 40 samples) and Di-n-Octylphthalate (DNBP) (16 out of 40 samples). The B2EHP was detected

the most frequently and at the highest concentrations of 0.1 mg/kg to 1,200 mg/kg with an average detected concentration of approximately 390 mg/kg. Similar to the presence of 244TM1P and 244TM2P, phthalate isomers, although most prevalent in the vicinity of the former Lake Poly area (SWMU No. 14), are located in subsurface soils throughout the Facility.

NNDPA was detected in 13 of 40 samples at concentrations ranging from 0.15 mg/kg to 3,400 mg/kg with an average detected concentration of approximately 265 mg/kg. Similar to the phthalate isomers, NNDPA, although more prevalent in the former Lake Poly area (SWMU No. 14), is located in subsurface soils throughout the Facility.

### Pesticides/PCBs

A review of the Pesticide/PCB data presented in Appendix L, Tab 3, shows that five pesticides were detected in one sample (BH12) and two pesticides in another sample (BH3). All detected concentrations were less than 0.15 mg/kg. PCBs were not detected in any subsurface soil samples.

# Inorganics

A comparison of the inorganic data presented on Plan 15, enclosed, and in Appendix L, Tab 3, to Site-specific background data (BH41 at GW-67 well nest) presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the subsurface soil samples exhibited elevated concentrations above background for the Site:

### Compound

## Max. Detected Conc. (mg/kg)

| Ammonia Calcium Chloride        | 400<br>16,000<br>170   |
|---------------------------------|------------------------|
| Chromium (total) Mercury        | 2,400<br>0.3           |
| Potassium<br>Sodium<br>Sulphate | 2,000<br>440<br>33,000 |

With the exception of mercury which was detected in three samples and chloride which was detected in 17 of 40 samples, all other above listed inorganic parameters were located in subsurface soil, above Site-specific background levels, throughout the Facility. As with the VOCs and SVOCs, the highest concentration of the inorganics were detected in the vicinity of former Lake Poly (SWMU No. 14).

# 6.4.3.3 Subsurface Soil Characterization Summary

The analytical data collected during the subsurface sampling program indicated that the following compounds were detected in subsurface soils throughout the Facility:

VOCs:

244TM1P, 244TM2P, Toluene, 2-Butanone, 2-Hexanone

and Acetone;

SVOCs:

Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl

Benzylphthalate (BBZP), Di-n-Octylphthalate (DNBP) and

N-Nitrosodiphenylamine (NNDPA); and

Inorganics:

Ammonia, Calcium, Chromium (total), Potassium,

Sodium and Sulphate

The highest concentrations of all the above compounds were detected in the vicinity of former Lake Poly (SWMU No. 14).

The atmospheric fate and transport mechanisms for 244TM1P and 244TM2P is characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from soil, surface water and groundwater. There are no available data found regarding water solubility but these compounds are known to be soluble in organic solvents such as benzene and chloroform. Soil adsorption cannot be predicted due to the lack of available Koc values in literature (see Appendix K).

As discussed for test pit samples, the phthalate isomers, B2EHP, BBZP and DNBP and NNDPA all exhibit high Koc values and will strongly adsorb to organic material in soils. Therefore, they have a very low potential for partitioning to the groundwater and will be virtually immobile in the soils. However, the migration of phthalate isomers and NNDPA may occur via sediment transport in surface water runoff. The inorganic compounds ammonia, calcium, potassium, sodium and sulphate all exhibit high solubilities and will, therefore, exhibit a high potential for partitioning to groundwater and/or surface water. Chromium is considered to be virtually bound to the soils under normal conditions (i.e. neutral pH), but its leachability from the soil will increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds.

# 6.5 GROUNDWATER CHEMISTRY

# 6.5.1 General

As discussed in Section 4.15.1, extensive groundwater sampling programs for chemical analyses were conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, 61 investigative groundwater samples were collected and analyzed for indicator parameters ammonia, chromium, chloride and sulphate and 11 investigative

groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate plus one additional investigative groundwater sample from one location for PCB analyses. Subsequently, two rounds of groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 114 investigative samples and second round consisted of 136 investigative samples including QA/QC requirements). During the first round, 19 investigative samples were collected for specific gravity analyses and 11 investigative samples were collected for hexavalent chromium analyses. During the second round, 18 investigative samples were collected for hexavalent chromium analyses. The locations of all Facility and Site monitoring wells are shown on Plan 3, enclosed.

Summaries of the groundwater samples collected for chemical analyses are presented in Table 4.8 (Groundwater Indicator Sampling Summary), Table 4.9 (Full Groundwater TCL/TAL Parameter Sampling Summary), Table 4.10 (First Round Groundwater Sampling Summary) and Table 4.11 (Second Round Groundwater Sampling Summary). A summary of the following data is presented in Appendix L:

- Tab 11 Summary of Detected Round 1 and 2 Groundwater Data;
- Tab 12 Average Detected Concentrations for Round 1 and 2 Groundwater Data;
- Tab 21 Summary of Groundwater Data Previous to Round 1;
- Tab 22 Summary of Round 1 and 2 Groundwater Data; and
- Tab 25 Summary of Non-Aqueous Phase Groundwater Data.

Supplementing the first and spood groundwater monitoring rounds was the EM geophysical well logging (see Section 4.12) which was used to aid in determining the vertical extent of the contaminated plume within the aquifer.

The following subsections present a summary of the analytical data for groundwater at the Site.

## 6.5.2 Groundwater Sampling Prior to Rounds 1 and 2

## 6.5.2.1 <u>Indicator Parameter Analyses</u>

As discussed in Section 4.15.1, an initial set of groundwater samples, consisting of 61 samples was collected from existing and newly installed monitoring wells. The samples were analyzed for groundwater indicator parameters ammonia, chromium (total), sulphate and chloride (see Table 4.8). These wells were sampled to assist in tracking the identified groundwater plume off the Facility such that additional CSA monitoring wells, if required, could be located. The data from these samples are presented in Appendix L, Tab 21.

These data have not been taken into account in the discussion which follows of groundwater chemistry at the Site or for conducting the risk assessment. The more complete data base set generated during Round 1 and 2 groundwater sampling (see Section 6.5.3) will be used for these purposes. It is to be noted that the indicator parameter data are consistent with the Round 1 and 2 groundwater data.

# 6.5.2.2 Full Parameter Analyses

In accordance with the CSA Work Plan, 11 Site wells were selected, based on historic data and indicator parameter analyses, to be sampled and applying for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.9). The data for these samples are presented in Appendix L, Tab 21.

These data were reviewed such that a Site Specific Parameter List (SSPL) could be selected for further and more extensive groundwater, surface water and sediment sampling and analyses. The SSPL selected included all of the above parameters (see Table 4.10) with the exception of PCBs. Aroclor 1016 was initially detected in one groundwater sample at a concentration of 1.6  $\mu$ g/L, collected from Facility well GW-54S. However, this well was subsequently resampled for PCBs, and PCBs were not detected. Also, PCBs were not detected in any test pit samples (see Section 6.3), surface soil samples (see Section 4.4.2), or subsurface soil samples (see Section 6.4.3). Therefore, it was determined not to include PCB analyses on the SSPL.

These data have not been taken into account in the discussion which follows of groundwater chemistry at the Site or in the risk assessment. The more complete data base set generated during Round 1 and 2 groundwater sampling (see Section 6.5.3) will be used for these purposes. It is to be noted that these data are consistent with the Round 1 and 2 groundwater data.

## 6.5.3 Round 1 and 2 Groundwater Data

A summary of detected Round 1 and 2 groundwater parameters is presented in Appendix L, Tab 11.

Based on these data, a groundwater contaminant plume was delineated which occupies a large portion of the center of the Facility, extends to the east boundary of the Facility, and extends to just past Highway 38 (Main Street) west of the Facility. A smaller portion of the plume extends to the southwest of the Facility. The extent of the plume is closely tied to the centers of the buried bedrock valleys (see Section 5.3) and occurs in a stratified nature hugging the bedrock surface along the centers of the bedrock valleys.

For the purposes of this section, inorganic and organic chemistry will be discussed in individual Sections 6.5.4 and 6.5.5, respectively. Following these discussions, a general discussion of groundwater contaminant source and fate and transport follows in Section 6.5.6.

## 6.5.4 Inorganic Parameters

Upon review of the extensive data base generated during the CSA, four inorganic "indicator" parameters were chosen for concentration plots for the purpose of illustrating contaminant distribution within the aquifer system. These parameters are: ammonia, chloride, chromium, and sulphate. All four parameters are distributed throughout the plume. In addition, pH values were plotted and show a strong correlation to the distribution of the indicator parameters within the groundwater system. These concentration plots, made of both the shallow portion and deep portion of the aquifer, are presented on Plans 20 through 29, enclosed.

As the plans show, the deep portion of the aquifer has been impacted. The source of the plume appears to be the central portion of the Facility. Based on information provided by Olin, this location corresponds to early aerial photographs that show two pits to the south of Building C and to the southeast of Lake Poly. It is also consistent with later aerial photographs showing the new warehouses, where the two previous pits had been, with the new acid pits and Lake Poly as shown on Figure 2.4. Stepan built the water treatment plant and lined lagoons in 1970. This plant discharged treated wastewater through the property until 1970 when the MDC sewer line was completed in 1972. After purchasing the Facility in 1980, Olin relined Lagoon I in 1981 and Lagoon II in 1983.

The data also show that in the shallow portion of the aquifer only the central portion of the Facility is impacted. Discussions of the extent of the four parameters in the deep and shallow portions of the aquifer are provided in the following subsections.

# 6.5.4.1 Deep Portion of Aquifer

### Chromium (Plan 20)

The distribution and extent of total chromium in the aquifer is consistent with the other indicator parameters. The highest concentration of chromium detected (3,600 mg/L) occurs just to the west of the Facility at well GW-42D. Further to the west, chromium was detected at wells GW-59D and GW-44D. Chromium concentrations drop off steeply around both the sides and front of the plume to the west. In the east central portion of the Facility the chromium concentrations also drop off quickly and do not extend as far as the East Ditch. Chromium was not detected in the southwest portion of the plume. Of the four indicator parameters, chromium shows the strongest affiliation with the low pH groundwater.

Based on information provided by Olin, this is consistent with the waste disposal from the Kempore process as it was operated between 1956 to 1967. During this time sodium dichromate was used in the process. The waste stream would contain, in addition to other constituents, chromium sulphate and sulphuric acid. This is consistent with the plume of low pH from the sulphuric acid and the chromium from the chromium sulphate. In 1967, the process was changed to use sodium chlorate instead of sodium dichromate. With the use of sodium chlorate, the waste stream would contain sodium chloride and sodium sulphate instead of chromium sulphate in addition to other constituents and sulphuric acid.

Chemical speciation was conducted in selected wells to determine the ratio of total chromium to hexavalent chromium (Cr VI) within the groundwater flow system. A ratio of approximately 10 percent Cr VI to total chromium was consistently observed.

## Sulphate (Plan 22)

The distribution and extent of sulphate in the aquifer is consistent with the other three indicator parameters with the highest concentrations seen on the west side of the Facility. Concentrations as high as 87,000 mg/L were detected at well GW-30DR. The wells which define the west edge of the plume are wells GW-59D, GW-70D, and GW-58D and delineate the 1,000 mg/L contour.

Elevated sulphate concentrations extend to the east side of the Facility in the deep portion of the aquifer as observed in well GW-50D. The eastern extent of sulphate in the aquifer is defined by the East Ditch. It is believed that the East Ditch serves as a regional discharge point for groundwater. This is supported by the fact that well GW-48D, installed east of the East Ditch, immediately across from the Plant B and well GW-74D installed east of the East Ditch in the East Bedrock Valley, immediately downgradient of the Site, did not detect any Facility-related organic compounds or any Facility-related inorganic compounds above background.

To the southwest of the Facility, sulphate was detected in well GW-40D at a maximum concentration of 1,400 mg/L. The southwestern extent of sulphate in the aquifer is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D, installed in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected sulphate at a level (50 mg/L) similar to background.

# Chloride (Plan 24)

The distribution and extent of chloride in the aquifer is consistent with the other indicator parameters. The highest concentrations of chloride are observed on and just to the west of the Facility in the deep portion of the aquifer. To the west, the 1,000 mg/L chloride concentration contour extends to wells GW-59D, GW-70D and GW-44D. Slightly elevated

chloride concentrations are observed in wells GW-58D (730 mg/L), GW-67D (280 mg/L), GW-61D (160 mg/L) and GW-64D (110 mg/L) which extend west to and across the Maple Meadow Brook wetland. As shown, the concentrations decrease with distance from the plume.

Along the east side of the Facility, elevated chloride extends to the Facility boundary at levels approaching 250 mg/L. Similar to sulphate, the eastern extent of elevated chloride is defined by the East Ditch. Again, it is believed that the East Ditch serves as a regional discharge point for groundwater. This is supported by the fact that well GW-74D installed east of the East Ditch in the East Bedrock Valley, immediately downgradient of the Site, detected chloride at a level (71 mg/L) similar to background levels.

To the southwest of the Facility, elevated chloride was detected in well GW-40D at a maximum concentration of 340 mg/L. The extent of elevated chloride to the southwest is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D, installed in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected chloride at a level (64 mg/L) similar to background levels.

#### Ammonia (Plan 26)

The distribution and extent of Ammonia in the aquifer is consistent with the other indicator parameters. The highest concentrations of Ammonia are observed on and just to the west of the Facility in the deep portion of the aquifer. Concentrations as high as 12,000 mg/L were detected at well GW-42D. To the west, the 1,000 mg/L Ammonia concentration contour extends to wells GW-45D and GW-59D.

Along the east side of the Facility, elevated Ammonia levels extend to the Facility boundary (1,000 mg/L), but drop off sharply prior to the East Ditch (<400 mg/L).

To the southwest of the Facility, elevated Ammonia was detected in well GW-40D at a maximum concentration of 520 mg/L. Similar to sulphate and chloride, the extent of elevated Ammonia to the southwest is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected Ammonia at a level (37 mg/L) similar to background levels.

## Other Inorganic Parameters (Appendix L, Tab 11)

Several other inorganic parameters are elevated above background levels. These parameters include: aluminum, calcium, magnesium, potassium and sodium. In general, the distribution of these parameters in the aquifer closely resembles the distribution of the four indicator parameters discussed above.

## Summary

Based on the Round 1 and 2 groundwater data, the plume is seen to emanate from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill area.

The plume has been delineated vertically with geophysical data showing the contaminants are stratified along the bottom of the aquifer. The plume is approximately 20 feet thick near wells GW-36 and GW-42D. The plume thins to the west and is approximately eight feet thick at GW-58D approximately 1,700 feet west of the Facility. Plan 30, enclosed, shows the areal extent of the plume and Plan 31, enclosed, shows two cross-sections through the plume which depict the vertical distribution of the contaminant plume based on chemical and EM geophysical data.

### 6.5.4.2 Shallow Portion of Aquifer

The impact of inorganic contaminants on the shallow portion of the aquifer is limited to the immediate Facility area. As Plans 21, 23, 25 and 27 illustrate, elevated levels of the four indicator parameters are observed in the center of the Facility extending to just past the Facility boundary to the west, and to the Facility boundary on the east. The highest levels of contaminants are seen in the area of the former pits/lagoons.

Based on information provided by Olin, this is consistent with the waste disposal from the Kempore process as it was operated between 1956 to 1967. During this time sodium dichromate was used in the process. The waste stream would contain, in addition to other constituents, chromium sulphate and sulphuric acid. This is consistent with the plume of low pH from the sulphuric acid and the chromium from the chromium sulphate. In 1967, the process was changed to use sodium chlorate instead of sodium dichromate. With the use of sodium chlorate, the waste stream would contain sodium chloride and sodium sulphate instead of chromium sulphate in addition to other constituents and sulphuric acid.

# 6.5.5 Organic Parameters

Organic compounds were detected during the CSA investigation in two primary areas of the Facility; the Plant B area, and the area around the center of the Facility near the former unlined pits/lagoons and Lake Poly. Sporadic and infrequent organic compounds were detected in deep wells to the west of the Facility. Plans 16 through 19 present groundwater data for selected organic parameters (see Section 6.2).

As shown on the Plans, the area around Plant B has been impacted by low levels of VOCs and high levels of the Bis(2)ethylhexyl Phthalate (B2EHP) and N-Nitrosodiphenylamine (NNDPA). The area affected is concentrated around the present groundwater interceptor well

system (see Section 2.3). In the interceptor wells, installed to stop oil from seeping into the East Ditch, a floating oil layer is removed periodically and sent off Site for incineration due to the high percent concentration of the dioctylphthalate present in the oil.

Based on information provided by Olin, this is consistent with historic operations in that area. Behind Plant B were six (6) 15,000 gallon storage tanks. Among the materials stored were dioctylphthalate, bis(2-ethylhexyl)phthalate and "Process Oil". An aerial photograph clearly shows a stream/ditch leaving the Plant B building and going to the East Ditch.

After Olin purchased the Facility a concrete floor and dike was constructed around the storage tank area. When the construction was in progress, due to contamination, soil removed from under and around these tanks was disposed of off Site in a secure landfill.

In the central portion of the Facility, several VOCs were detected in both the shallow and deep portions of the aquifer. West of the Facility, VOCs were detected primarily in the deep portion of the aquifer with no apparent consistent distribution. The principal detected VOCs include Acetone, Toluene, 244TM1P, 244TM2P and Bromoform. SVOCs were also detected in this area and to the west of the Facility. The principal detected SVOCs included phenolic compounds and NNDPA, which was detected primarily on the Facility only.

Sporadic and infrequent low levels of pesticides ( $<0.3\,\mu g/L$ ) were detected in various wells around the Facility.

#### 6.5.6 Groundwater Chemical Source Areas

#### 6.5.6.1 General

Section 2.2 of this report outlines the process and waste disposal history at the Facility from 1953 to 1986 when the plant closed. As discussed in Section 2.2, wastes from various processes entered unlined pits located near the center of the Facility from approximately 1953 to 1970. Other wastes including yard and process spills and process drains which were directed into an on-Site drainage system which discharged into unlined Lake Poly located along the west side of the Facility. A summary of the raw materials, products and waste by-products included in these waste streams is provided in Table 2.1.

Based on information provided by Olin, in 1969 Stepan entered into a Consent Order to install a waste treatment plant to neutralize the acidic waste and lined lagoons. The plant was completed in 1970. The treated wastewater was discharged through the property until 1972 when the Metropolitan District Commission sewer line was completed.

After Olin purchased the Facility, Lagoon I was relined in 1981 and Lagoon II in 1983.

## 6.5.6.2 Inorganic Parameters

Based on the available knowledge of chemicals which were directed into the unlined pits and Lake Poly and a review of aerial photographs, these areas are considered to be the primary source of the inorganic plume associated with the Facility. Though it is 20 years since discharge into the pits ceased, elevated concentrations of the Facility-related waste compounds in groundwater correlate to the position of these areas. In addition, soil samples collected from borings completed in the Lake Poly area

exhibited the highest levels of chromium concentrations in the subsurface soils.

The majority of the inorganic contamination appears to emanate from the central area of the Facility. To some extent, the Sulphate Landfill to the southwest of the Facility, may be contributing to sulphate, chloride and ammonia concentrations in this area.

### 6.5.6.3 Organic Parameters

As discussed in Section 6.5.5, organic contaminants were identified in two primary areas at the Facility; the Plant B area, and the area around the central portion of the Facility. Also of note are the elevated levels of organic compounds at well GW-49 located off the Facility to the east. Following is a discussion of the potential sources of these contaminants in the aquifer.

Organic contamination in the Plant B area has been attributed to the spills, leaks and release of oily compounds associated with manufacturing processes and storage tanks in this area. An unknown amount of oil was released over the course of operations at Plant B. Based on information provided by Olin, in employee interviews, this area seemed to be mentioned most frequently concerning spills, leaks and discharges that occurred in the past. In aerial photographs a stream can be seen leaving the Plant B building and proceeding to the East Ditch.

When Olin installed the concrete floor and dike walls around the Plant B storage tanks, a large amount of contaminated soil was disposed of off Site at an apprecial disposal facility.

To clean up the banks of the East Ditch behind the Storage Tanks in the Plant B area, in 1982 Olin removed a portion of the bank and replaced it with clean fill. Currently, the oil is being prevented from

impacting the East Ditch by a pump and treat system that is discharged through a NPDES permitted outfall (see Section 2.3).

The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources; the discharge of yard spills, process drains and oily wastes from the Opex process to Lake Poly, the disposal of organic wastes to the pits, and the disposal of drums containing organic compounds beneath the ground surface.

No apparent correlation can be made between the Facility and the organic compounds detected in well GW-49. Also, as discussed in Section 6.7 (Sediments), elevated levels of VOCs, which were not detected at the Facility, are detected in the sediments downstream of this location.

## 6.5.7 Groundwater Contaminant Transport

To assess contaminant transport, hydrogeologic conditions and chemical data must be integrated. Following is a discussion of contaminant transport in the groundwater. Appendix K presents a detailed discussion on the fate and transport of Site-specific contaminants in the environment.

# 6.5.7.1 Inorganic Parameters

The extent of the plume based on the Round 1 and 2 groundwater data has been discussed in Sections 6.5.4 and 6.5.5. The plume extends to the west just west of Highway 38 (Main Street), edges off the Facility boundary to the East Ditch, and edges off the Facility to the southwest in the vicinity of the Sulphate Landfill. Vertically, the plume is stratified occupying the bottom of the aquifer ranging in thickness from approximately 20 feet on the east at well GW-42D and thins to approximately eight feet at well GW-58D, approximately 1,700 feet west of the Facility. It has been

interpreted that the plume is stratified due to the density difference between the heavier waste discharged and natural groundwater. Table 6.2 provides a summary of specific gravity analyses performed on selected wells at the Site. A review of these data shows that the shallow groundwater system exhibits a specific gravity of 1.005 to 1.015. The deep wells immediately adjacent to the west side of the Facility exhibit a specific gravity of approximately 1.1. Further to the west the specific gravity in the deep well GW-45D decreased to 1.06. Near the edge of the plume, the deep wells exhibit specific gravity around 1.005, similar to that measured in the shallow monitoring wells at the Site.

A discussion of the groundwater flow conditions was provided in Section 5.4. In summary, a zone of regional groundwater divide was identified in the area west and north of the Facility. Groundwater flow west of this divide is towards the northwest into the Ipswich River hydrologic basin and groundwater flow east of the divide is towards the southeast and Aberjona River hydrologic basin. Shallow groundwater at the Facility discharges into the ditch complex surrounding it.

# Plume Migration

As is apparent, the dense plume has migrated in a direction opposite of the natural groundwater flow system to the immediate west of the Facility. The potential reason for this is the wastewater, being more dense than the natural groundwater, settled through the aquifer, flowing by force of gravity along the slope of the bottom of the aquifer (bedrock valley surface). The relatively narrow bedrock channel which runs just below the central portion of the Facility, provided a route for the migration of the plume to the west. The opposing force of natural groundwater flow to the southeast is rather weak in the area west of the Facility as the berizontal hydraulic gradients are very low.

It is believed that as long as the dense acidic wastewater was being discharged at relatively high volumes, the driving force of hydraulic gradients caused by gravity was predominant in influencing the

flow of the contaminants to the west, against the natural groundwater flow direction. In effect, over time, the plume was being "pushed" to the west by the recharge of higher density wastewater into the aquifer.

### Factors Affecting Plume Migration

Three factors are believed to have had the major influence over dense contaminant migration in the aquifer: the slope of the bedrock surface; the hydraulic forces generated from recharge of the wastewater; and the dilution effects at the plume edge which control pH. Following is a discussion of these factors.

Bedrock Slope

The slope of the bedrock surface is steeper in the area just west of the Facility, and gradually flattens out west of Highway 38 (Main Street). It is believed that the flattening out of the slope of the bottom of the aquifer subsequently results in decreased movement of the plume via gravity.

Wastewater Discharge Effects on Hydraulic Head

For approximately 17 years, acidic wastewater was recharged into the aquifer, creating an artificial hydraulic head which increased the migration rate of the plume. When the discharge of wastewater ceased, the artificial hydraulic head was eliminated, resulting in lower migration rates of contaminants. It is believed that the effects of the natural groundwater flow system has minimal effect in retarding the movement of the dense portion of the plume.

Combined Effects of Slope and Hydraulic Head

The volume of the dense portion of the plume is now fixed, and when considered with the factor of decreased slope of the bedrock surface with distance from the Site, the hydraulic gradients caused by gravity

as a driving mechanism for the plume will decrease over time. As the hydraulic gradients decrease, it is believed that the dense portion of the plume has reached a "physical" equilibrium within the aquifer flow system or is moving very slowly.

Effects of Dilution on pH and Plume Mobility

The concentrations of chromium in the plume is closely tied to the pH levels, with the solubility of the chromium being greatly increased with increasing acidic conditions. The chromium concentration plans (Plans 20 and 21) illustrate that the "concentration gradients" of the plume are steep around all sides. This is believed to be a result of the rapid rise in pH from the center portion of the plume to the plume edges. The increase in pH due to dilution has greatly decreased the solubility of the chromium on the plume edges. It is believed that the effects of the natural groundwater diluting the main portion of the dense plume is a significant factor in restricting the plume migration. Over time, the plume will reach chemical equilibrium within the aquifer system.

The redox potential of the groundwater may also influence the mobility of the inorganic parameters (chromium, sulphate and ammonia). Changes in the ionic state of these parameters will affect the solubility and mobility of the parameters in the aquifer.

Conditions Beyond the Dense Portion of the Plume

In well GW-62BR, which is screened in the bedrock below the sand and gravel aquifer, elevated levels of three of the four indicator parameters are noted. Concentrations of sulphate (160 mg/L), chloride (110 mg/L) and ammonia (100 mg/L) have been detected in well GW-64D. This well is located west of the dense portion of the plume in the vicinity of the Butters Row Pumping Station. It is believed that the elevated levels above background for these parameters in this well is the result of the "dissolution" and migration in the groundwater flow system away from the

main, dense portion of the plume. Since the pH has increased greatly from inside the main body of the plume, the solubilities of these compounds within the aquifer has decreased orders of magnitude. It is believed that the migration of these compounds west of the main plume body is a function of the natural groundwater flow system, as opposed to the gravity driven flow mechanism proposed for the dense portion of the plume. Those parameters (such as chromium) which are more dependent on low pH for increased solubility and hence mobility within the groundwater system, should not migrate beyond the dense, low pH portion of the plume.

Contaminant Flow Into the Site Ditches

A portion of the plume is at present discharging to the ditch complex surrounding the Facility as evidenced by the observed flocculant material and chemical analysis of surface water and sediment. This discharge is most likely from the shallow portion of the aquifer on the west side of the Facility. The chemical concentration plots of the shallow aquifer also indicate contaminant flow to, but not beyond, the south and east ditches. Groundwater elevation data show flow towards the ditch as well.

# 6.5.7.2 Organic Parameters

Organic compounds in groundwater have been detected in two principle locations as discussed in Section 6.5.4. The Plant B area organic contaminants historically were observed discharging to the east ditch; however, the area is currently under control by an interceptor well system, with control of the oil seeps being achieved. Therefore, no discussion of organic contaminant transport will ensue for this area.

In the central portion of the Facility, and to the west of the Facility, organic compounds are detected in a random distribution pattern and no organic "plume" delineation was attempted. It is likely that the scattered nature of the disposal areas, combined with the irregular timing of waste

releases has resulted in this random pattern. Based on the surface water data, at least a portion of the organic contaminants are discharging to the ditches.

As most of the organic contaminants were detected only in deep wells to the west of the Facility, it is likely that these compounds were transported with the dense inorganic plume via gravity flow to the west. Several of the compounds which are detected on the Facility are detected only sporadically, or are not detected at all off the Facility. Although no detailed study of organic compound fate was conducted, it is likely that many of the SVOCs have adsorbed to the aquifer materials.

## 6.6 SURFACE WATER CHEMISTRY

### 6.6.1 General

As discussed in Section 4.15.2, an extensive surface water sampling program for chemical analyses was conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, two rounds of surface water samples, were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 22 samples and second round consisted of 36 samples including QA/QC requirements). During the first round, 2 samples were also collected for hexavalent chromium analysis and during the second round 6 samples were collected for hexavalent chromium analysis (see Tables 4.12 and 4.13). Plan 7, enclosed, presents surface water sampling locations.

A summary of the following data is presented in Appendix L:

- Tab 13 Summary of Detected Round 1 and 2 Surface Water Data;
- Tab 14 Average Detected Concentrations for Round 1 and 2 Surface Water Data;

- Tab 23 Summary of Surface Water Data Previous to Round 1; and
- Tab 24 Summary of Round 1 and 2 Surface Water Data.

Plan 32, enclosed, presents a summary of selected parameters (see Section 6.2) for Rounds 1 and 2 surface water samples. The following subsections present a summary of the analytical data for surface water.

### 6.6.2 Surface Water Characteristics

VOCs

A review of the VOC data presented on Plan 32, enclosed and Appendix L, Tab 13 indicates sporadic and infrequent detection of VOCs in the surface water with the exception of 244TM1P and 244TM2P. 244TM1P was detected at 16 of 30 surface water sampling locations and 244TM2P was detected at 13 of 30 surface water sampling locations. The maximum detected concentration of 244TM1P was 200 µg/L with an average detected concentration of approximately 17 µg/L and the maximum detected concentration of 244TM2P was 81 µg/L with an average detected concentration of approximately  $9 \mu g/L$ . The maximum concentrations of both 244TM1P and 244TM2P were detected at location SW-15, the furthest most upstream sample in the West Ditch bordering the Facility. Samples from the West Ditch also exhibited the highest detectable levels of Acetone at 93 µg/L. As discussed in Section 5.4.3.2, shallow groundwater flow along the west central portion of the Site discharges to the West Ditch. This area is downgradient and adjacent to the former lagoons (SWMU No. 10), acid pits (SWMU No. 15), former Lake Poly (SWMU No. 14) and the two pits under the existing warehouses. As discussed in Section 6.4, the maximum subsurface soil concentrations for 244TM1P, 244TM2P, and Acetone were all detected in the area of former Lake Poly, upgradient to the West Ditch.

In the northern branch of the South Ditch, 244TM1P and 244TM2P, were detected at all locations. However, in the southern branch of the South Ditch, neither 244TM1P and 244TM2P were detected in any sample.

In the East Ditch bordering the Facility, the following halogenated VOCs were detected in the surface water samples: 1,1,1-Trichloroethane(111TCE), 1,1-Dichloroethene (11DCLE), Chloroethane (C2H5CL), Methylene Chloride (C2CL2), and Trichloroethene (TRCLE). The highest concentrations of each of these parameters were typically detected at sample locations SW-1, SW-29 and SW-30. As shown on Plan 32, enclosed, SW-1, SW-29 and SW-30 are located in the East Ditch upstream of the Facility. This suggests that the source of the halogenated VOCs is located upstream of the Facility. This is supported by the fact that the halogenated VOCs were not typically detected in Facility test pit samples, surface and subsurface soils or Facility groundwater.

244TM1P and 244TM2P were also detected in the East Ditch, specifically at locations SW-2 and SW-3. These two locations are situated immediately downstream of the Plant B area (SWMU No. 13 and No. 23) and the black area east of Plant D (SWMU No. 26) where surface soils were previously removed, respectively. 244TM1P and 244TM2P were also detected in the East Ditch at locations SW-25, SW-26 and SW-27. The furthest downstream sample in the East Ditch, SW-28 did not detect 244TM1P and 244TM2P. Toluene and 2-Hexanone (MNBK) were also detected in the East Ditch, specifically at locations SW-29 and SW-30. The detected concentrations for Toluene at SW-29 and SW-30 were 140 µg/L and 240 µg/L, respectively. The detected concentrations of 2-Hexanone (MNBK) at SW-29 and SW-30 were 33  $\mu$ g/L and 39  $\mu$ g/L, respectively. These locations are situated immediately upstream of the Facility. This suggests that the source for these contaminants is located upstream of the Facility. Further downstream, the detected concentration of Toluene at SW-23, SW-24, SW-25, SW-26, SW-27 and SW-28 was 42  $\mu$ g/L, 76  $\mu$ g/L, 70  $\mu$ g/L, 56  $\mu$ g/L, 26  $\mu$ g/L, and 5  $\mu$ g/L, respectively. The two samples immediately upstream of location SW-23, locations SW-4 and SW-5, did not detect Toluene. As discussed in Section 6.5, the groundwater at monitoring well GW-49 exhibited Toluene at a concentration of 12,000  $\mu$ g/L. The Toluene at well GW-49 is not considered to be associated with the Facility. As shown on Plan 3, enclosed, well GW-49 is located east of the Facility, downstream of sample location SW-5 but upstream of sample locations SW-23, SW-24, SW-25, SW-26, SW-27 and SW-28. This strongly suggests that the source of Toluene at locations SW-23 through SW-28 is associated with a source located east of the Facility.

### **SVOCs**

A review of the SVOC data presented on Plan 32, enclosed, and Appendix L, Tab 13 indicate sporadic and infrequent detection of SVOCs in the surface water with the exception of Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA) and Phenol.

B2EHP was detected at 21 of 30 surface water sampling locations. The maximum concentrations of B2EHP were detected in the northern branch of the South Ditch at location SW-8 (48  $\mu$ g/L) and in the East Ditch at location SW-26 (74  $\mu$ g/L). All other detected concentrations of B2EHP were below 14J  $\mu$ g/L.

NNDPA was detected at 9 of 30 surface water sampling locations. Similar to 244TM1P and 244TM2P, the maximum concentration of NNDPA was detected in the West Ditch at upstream location SW-15. As discussed above, the West Ditch receives shallow groundwater discharge from the Facility. As discussed in Section 6.4, the maximum subsurface soil concentration for NNDPA is in the area of former Lake Poly (SWMU No. 14).

Phenol was detected at 6 of 30 surface water sampling locations, with five of the six detections occurring in the West Ditch. The maximum concentration of phenol detected in the surface water was 3J µg/L.

At location SW-15 (West Ditch, upstream sample) low levels of various PAHs were also detected at concentrations ranging from  $3J \mu g/L$  to  $33 \mu g/L$ . This is the only surface water location which detected PAHs.

### Pesticides

With the exception of one detected concentration of Endrin Aldehyde (ENDRN) at SW-5 (East Ditch) at a concentration of 0.11  $\mu$ g/L, location SW-15 was the only location which exhibited detected concentrations of pesticides. At location SW-15 (West Ditch, upstream sample), six pesticides were detected with a maximum concentration of 0.49  $\mu$ g/L.

### Inorganics

A review of the inorganics surface water data presented on Plan 32; enclosed, and Appendix L, Tab 13, indicates that the following inorganic parameters were elevated above acute and/or chronic U.S. EPA Ambient Water Quality Criteria (AWQC) for protection of freshwater aquatic life:

|                        |            | er AWQC |                                    |                        |                |
|------------------------|------------|---------|------------------------------------|------------------------|----------------|
|                        | (µg/I      | (a)     | Max. Detected Concentration (μg/L) |                        |                |
| Compound               | Acute      | Chronic | West Ditch                         | South Ditch            | East Ditch     |
| Aluminum (b)           | <i>7</i> 5 | 87      | 59,000                             | 21,000                 | 3,500          |
| Ammonia <sup>(b)</sup> | 23,000     | 2,100   | 120,000                            | 110,000                | 34,000         |
| Calcium                |            |         | 180,000                            | 140,000                | <i>57,</i> 000 |
| Chloride               | 000,088    | 230,000 | 590,000                            | 190,000                | 210,000        |
| Chromium VI            | 16         | 11      | 400J                               | 74J                    | 270            |
| Chromium III (c)(d)    | 1,700      | 210     | 12,000                             | 1 <i>,</i> <b>7</b> 00 | 410            |
| Copper (d)             | 18         | 12      | 12()                               | ND                     | ND             |
| Iron                   |            | 1,000   | 20,000                             | 72,000                 | 5,400          |
| Sodium                 |            |         | 250,000                            | 200,000                | 120,000        |
| Sulphate               |            |         | 3,000,000                          | 590,000                | 270,000        |
| Zinc (d)               | 120        | 110     | 190                                | 96                     | 200            |

#### Notes:

- (a) All values are from 1980, 1984, or 1988 U.S. EPA Ambient Water Quality Criteria (AWQC) documents.
- (b) Criteria are pH dependent and/or temperature dependent. Aluminum assumed at pH 6 to pH 9, and total ammonia assumed at pH 7.0, and 20 degrees Celsius.
- (c) Surface water analytical data reported as total chromium.
- (d) Hardness dependent criteria (assumed hardness of 100 mg/L, as CaCO<sub>3</sub>).

As indicated by the above data, the maximum concentration of all the inorganic parameters, except zinc, decrease as one moves downstream from the West Ditch, to the South Ditch, to the East Ditch.

The highest levels of inorganic parameters were typically detected at SW-16 in the West Ditch. Field observations conducted during sampling noted considerable discoloration of the sediment in the area around SW-16. Heavy red and white material was noted on the West Ditch bottom, which appeared to be a flocculant material. Downgradient from this location, levels of inorganic parameters stabilize and in some cases, drop off.

No significantly elevated levels of inorganic parameters were detected in the ditch above the junction of the South Ditch complex. Field observations conducted during sampling noted a black oily sheen on sediments in the South Ditch sampling locations. Below the junction, levels of inorganic parameters increase at low levels, due to the input from the West Ditch.

# 6.6.3 <u>Surface Water Characterization Summary</u>

The analytical data collected during the surface water sampling program indicated the following compounds were detected in surface waters at the Facility:

VOCs:

244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone;

SVOCs:

Bis(2-ethylhexyl)Phthalate (B2EHP),

N-Nitrosodiphenylamine (NNDPA), and Phenol; and

Inorganics:

Aluminum, Ammonia, Calcium, Chloride, Chromium

(III and VI), Copper, Iron, Sodium, Sulphate and Zinc.

The highest concentrations of 244TM1P, 244TM2P, Acetone, NNDPA, Phenol and all the inorganics except for iron, were detected in the West Ditch. The West Ditch receives groundwater discharge from the Facility. The highest concentrations of B2EHP and iron were detected in the South Ditch. The South Ditch also receives groundwater discharge from the Facility. It is also important to note that the only significantly elevated levels of iron detected in either the test pit samples or soil samples collected at the Facility were detected in the drum sample from test pit 21 (near the South Ditch) and in the hand auger sample collected from SWMU No. 33 (also near the South Ditch at GW-55 well nest).

In addition to the above noted VOCs detected at the Facility, halogenated VOCs: 111TCE, 111DCLE, C2H5CL, C2CL2 and TRCLE were detected in the upstream portions of the East Ditch and are probably attributed to a source located upstream of the Facility. Also, the concentrations of Toluene at the furthest upstream samples in the East Ditch is probably attributable to a source located upstream of the Facility.

are highly water soluble and once in the surface water, these compounds will rapidly volatilize as indicated by their moderate to high Henry's Law Constants. Adsorption and sedimentation are not expected to be a predominant removal process.

However, for B2EHP, NNDPA and Phenol, volatilization will not be significant but adsorption and sedimentation will be predominant. Koc values for B2EHP and NNDPA indicate very high adsorption potential and thus, minimal mobility in the surface water. However, for Phenol, a low

Koc value of 129 indicates low adsorption potential and thus, high tendencies to partition to the water.

All inorganics exhibit high solubilities and will, therefore, show high potential for partitioning to surface water.

Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds in surface water.

### 6.7 SEDIMENT CHEMISTRY

### 6.7.1 General

As discussed in Section 4.15.3, an extensive sediment sampling program for chemical analyses was conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, two rounds of sediment samples, were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 25 samples and second round consisted of 35 samples including QA/QC requirements). During the first round, 2 samples were also collected for hexavalent chromium analysis and during the second round, 8 samples were collected for hexavalent chromium analysis (see Tables 4.14 and 4.15). Plan 7, enclosed, presents sediment sampling locations.

A summary of the following data is presented in Appendix L:

- Tab 9 Summary of Detected Round 1 and 2 Sediment Data;
- Tab 10 Average Detected Commentations for Round 1 and 2 Sediment Data;
- Tab 18 Summary of Sediment Data Previous to Round 1; and
- Tab 19 Summary of Round 1 and 2 Sediment Data.

Plan 33, enclosed, presents a summary of selected parameters (see Section 6.2) for Rounds 1 and 2 sediment samples. The following subsections present a summary of the analytical data for sediments.

## 6.7.2 Sediment Characteristics

VOCs

A review of the VOC data presented on Plan 33, enclosed and Appendix L, Tab 9 indicates sporadic and infrequent detection of VOCs in the sediments with the exception of 244TM1P, 244TM2P, Acetone and Toluene. 244TM1P was detected at 23 of 29 sediment sampling locations and 244TM2P was detected at 20 of 29 sediment sample locations. Acetone was detected in 18 of 29 sediment locations and Toluene was detected in 14 of 29 sediment locations. It should be noted that Acetone was only detected in the first round sediment samples and Toluene was mainly detected in only the second round sediment samples.

The maximum detected concentration of 244TM1P was 28 mg/kg with an average detected concentration of approximately 1.6 mg/kg and the maximum detected concentration of 244TM2P was 9.4 mg/kg with an average detected concentration of approximately 0.62 mg/kg. The maximum concentrations of both 244TM1P and 244TM2P were detected at location SW-13 in the West Ditch bordering the Facility. The samples from the West Ditch also exhibited the highest detectable levels of Toluene at a concentration of 1.1J mg/kg. In addition, the West Ditch samples also exhibited frequent detection of Bromoform (CHBR3) (0.14 mg/kg), Dibromochloromethane (DBRCLM) (0.035 mg/kg) and Ethylbenzene (CTC6H5) (0.71 mg/kg). These compounds were not detected in other ditch sediments.

As discussed in Section 6.6.2, shallow groundwater flow along the west central portion of the Site discharges to the West Ditch. This

area is downgradient and adjacent to the former lagoons (SWMU No. 10), acid pits (SWMU No. 15), former Lake Poly (SWMU No. 14), and the two pits under the existing warehouses. As discussed in Section 6.4, the maximum subsurface soil concentrations for 244TM1P, 244TM2P and Toluene were all detected in the area of former Lake Poly, upgradient to the West Ditch. Toluene was also detected in drum samples collected from test pits 6, 7 and 8 (SWMU No. 19). General field observations made during the CSA noted an oily product in the sediment of the West Ditch.

In the northern branch of the South Ditch, 244TM1P and 244TM2P were detected at all locations. The maximum concentration detected in the South Ditch for 244TM1P was 4.7J mg/kg and for 244TM2P was 1.5J mg/kg. However, in the southern branch of the South Ditch, only trace amounts of 244TM1P (0.004] mg/kg) were detected in two samples. The maximum concentration of Acetone was detected at location SW-8 in the South Ditch at a concentration of 1.7 mg/kg. This location is adjacent to the central pond located on the Facility. A halogenated VOC, 11DCLE was also detected at three locations in the South Ditch with a maximum concentration at location SW-8 of 0.034J mg/kg. 2-Butanone (MEK) and 2-Hexanone (MNBK) were also detected in two sediment samples, locations SW-8 and SW-9, at maximum concentrations of 0.074J mg/kg and 0.036 mg/kg, respectively. Both of these sample locations are adjacent to the central pond at the Facility. General field observations made during the CSA noted an oily material in the sediments between the junction of the West Ditch and South Ditch and the central pond.

Based on information provided by Olin, the oily material is probably a waste from the OPEX process which took place in Plant A. Oil was used in the process to reduce the flammability of the product. Until about 1970, caces oil, spills and wash downs would be discharged to Lake Poly which emptied into the West Ditch. The drainage lines and Lake Poly are shown on Figure 2.3. In a 1969 report, for National Polychemicals Inc., an oily component was observed as a "Floating material from the Lake Poly sewer...". It should be noted that this oily material was observed in sediment samples

109

taken from the ditches and was also evident in the south ditch "central pond".

The waste treatment system was installed by Stepan in 1970 and included an oil removal step before treatment.

244TM1P and 244TM2P were detected in most samples collected from the East Ditch at maximum concentrations of 0.2 mg/kg and 1.1 mg/kg, respectively at SW-25.

Trichloroethene (TRCLE) was detected in the surface sediments in the East Ditch at locations SW-4, SW-5, and SW-6 at maximum concentrations of 0.005J mg/kg, 0.05 mg/kg and 0.01 mg/kg, respectively. Further downstream TRCLE was detected at locations SW-23, SW-24, SW-25 and SW-27 at maximum concentrations of 0.15 mg/kg, 0.024J mg/kg, 0.029 mg/kg, and 0.02 mg/kg, respectively. TRCLE was detected in three upstream samples in the East Ditch at SW-2, SW-29 and SW-30 at a concentration of 0.002J mg/kg, 0.002J mg/kg and 0.018 mg/kg, respectively. The concentration in the upper portion of the East Ditch suggests that the source of TRCLE is associated with a source located upstream of the Facility.

**SVOCs** 

A review of the SVOC data presented on Plan 33, enclosed, and Appendix L, Tab 9, indicates frequent detection of various PAHs, phthalate isomers and N-Nitrosodiphenylamine (NNDPA).

The PAHs detected in the sediments include:

|                         |          | Max. Detected Concentration ( |         | ion (mg/kg)    |
|-------------------------|----------|-------------------------------|---------|----------------|
|                         |          | West                          | South   | East           |
| Compound                |          | Ditch                         | Ditch   | Ditch          |
| Acenaphthylene          | (ANAPNE) | -an                           | -       | 0. <b>2</b> 5J |
| Anthracene              | (ANTC)   | -                             | -       | 0.52J          |
| Benzo(a)Anthracene      | (BAANTR) | 2.1J                          | 0.095   | 1.7J           |
| Benzo(a)Pyrene          | (BAPYR)  | 0.6J                          | 0.10    | 2.0            |
| Benzo(b)Fluoranthene    | (BBFANT) | 1.2                           | 0.18    | 4.4            |
| Benzo(g,h,i)Perylene    | (BGHIPY) | 0.45J                         | 0.083   | 2.1            |
| Benzo(k)Fluoranthene    | (BKFANT) | 0.29J                         | -w-     | 1.4]           |
| Chrysene                | (CHRY)   | 0.73J                         | 1.3J    | 3.4            |
| Dibenzo(a,h) Anthracene | (DBAHA)  | 0.12                          | -       | 0.43           |
| Dibenzofuran            | (DBZFUR) | 5.9J                          | <u></u> | 0. <b>2</b> 2J |
| Fluoranthene            | (FANT)   | 4.0                           | 0.092   | 4.5            |
| Indeno(1,2,3-cd)Pyrene  | (ICDPYR) | 0.56                          | 13.0J   | 1.3            |
| Naphthalene             | (NAP)    | 2.2]                          | -       | 2.7            |
| Phenanthrene            | (PHANTR) | 34.0                          | 4.2J    | 1.9            |
| Pyrene                  | (PYR)    | 9.1J                          | 0.93J   | 3.5            |

As shown above, ten of the 15 PAHs detected in the sediments are at their highest concentrations in the East Ditch and three of the 15 PAHs detected in the sediments are at their highest concentrations in the West Ditch.

As discussed in Appendix K, PAHs are ubiquitous in the environment and are formed during the incomplete combustion of virtually all forms of organic materials. As noted above, the highest concentrations of 13 of the 15 PAHs were detected in either the West Ditch or the East Ditch. Both ditches run parallel to rail lines. It is presumed that at one time, the trains that used the rail system utilized coal as a fuel source. The levels of PAHs found in the Site samples parallel those for industrial and urban development. A comparison of the PAHs in the sediments to typical concentrations in urban soils (see Table K.5, Appendix K) shows that the PAHs detected in the sediments at the Site are within typical urban soil concentration ranges.

The phthalate isomers detected in the sediments include:

|                            |         | Max. Detected Concentration (mg/) |              |       |
|----------------------------|---------|-----------------------------------|--------------|-------|
|                            |         | West                              | South        | East  |
| Compound                   |         | Ditch                             | Ditch        | Ditch |
| Bis(2-ethylhexyl)Phthalate | (B2EHP) | 200,000                           | 60,000J      | 9,300 |
| Butyl Benzylphthalate      | (BBZP)  | 160J                              | 1 <i>7</i> J | 0.4J  |
| Di-N-Butylphthalate        | (DNBP)  | 1,400J                            | 60           | 0.23  |
| Di-N-Octylphthalate        | (DNOP)  | 2.1                               | 24J          | 10    |
| Diethylphthalate           | (DEP)   | 0.79J                             | w            | -     |
| Dimethylphthalate          | (DMP)   | 0.18                              | 0.53         |       |

B2EHP was detected at 28 of 29 locations sampled.

Concentrations generally decreased from the West Ditch, to the South Ditch, to the East Ditch. The furthest downstream sample in the East Ditch (SW-27) exhibited a concentration of 80 mg/kg. BBZP, DNBP and DNOP were also frequently detected, however, were mostly limited to the West and South Ditches. DEP and DMP were sporadically and infrequently detected.

NNDPA was detected at 22 of 29 sediment sample locations. The maximum concentration of NNDPA was detected in the West Ditch at location SW-13 (6,200J mg/kg). In the South Ditch, NNDPA was detected at location SW-9 (adjacent to the central pond) at a maximum concentration of 720J mg/kg. The maximum concentration of NNDPA in the East Ditch was at location SW-23 at a concentration of 2.1 mg/kg. The concentration of NNDPA dropped off to 0.8 mg/kg at location SW-24 and to 0.29 mg/kg at SW-27, the furthest sample downstream. The data show the NNDPA is prevalent in the sediments and decreases from the West Ditch, to the South Ditch, to the East Ditch.

As discussed in previous sections, groundwater flow from the Facility discharges to all three ditch systems. The West Ditch is located the closest to the former lagoon areas (SWMU No. 9 and 10), the former acid pito (SWMU No. 15), the former Lake Poly (SWMU No. 14), and the buried waste drums (SWMU No. 19), and the pits located under the existing warehouses. The South Ditch also receives groundwater discharge from some of these

areas. As discussed in Appendix K, phthalate isomers and NNDPA, due to their high  $K_{OC}$  values, will readily adsorb to suspended matter and sediments.

### Pesticides

A review of the Pesticides data presented in Appendix L, Tab 9, shows that all pesticides were detected sporadically and infrequently. Endosulfan Sulphate (ESFSO4) and Endrin Aldehyde (ENDRNA) were the most frequently detected pesticides. ESFSO4 was detected at 6 of 30 sample locations at a maximum concentration of 0.24 mg/kg (SW-15) and ENDRNA was detected at 10 of 30 sample locations at a maximum concentration of 6.5 mg/kg (SW-3).

### Inorganics

A comparison of the inorganic data presented on Plan 33, enclosed, and in Appendix L, Tab 9, to Site-specific background surface soil data presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the sediment samples exhibited elevated concentrations above background for the Site:

|                  | Max. Detected Concentration (mg/kg) |        |         |
|------------------|-------------------------------------|--------|---------|
|                  | West                                | South  | East    |
| Compound         | Ditch                               | Ditch  | Ditch   |
| Aluminum         | 150,000                             | 13,000 | 60,000  |
| Antimony         | 120                                 | 88     | 33      |
| Ammonia          | 1,000                               | 410    | 410     |
| Calcium          | 910                                 | 1,900  | 9,900   |
| Chloride         | 1,400                               | 240    | 240     |
| Chromium VI      | 300J                                | 140J   | 33J     |
| Chromium (total) | 8,900                               | 2,900  | 3,000   |
| Iron             | 83,000                              | 13,000 | 140,000 |
| Mercury          | 0.96                                | 1.2J   | 1.3     |
| Sodium           | 1,600                               | 500    | 560     |
| Sulphate         | 6,000                               | 3,200J | 18,000  |
| Zinc             | 110                                 | 78     | 1,100   |

All of the above listed inorganic parameters were present in sediments above Site-specific background levels across the Facility.

113

Parameter concentrations typically decrease from the West Ditch to the South Ditch and then remain relatively consistent in the East Ditch. The furthest downstream sample collected in the East Ditch (SW-27) shows a total chromium concentration at 1,900 mg/kg, a sulphate concentration of 4,300 mg/kg, an ammonia concentration of 370 mg/kg and a chloride concentration of 240 mg/kg. For inorganic parameters, antimony, iron and mercury the concentrations are relatively constant across the Site sediments.

# 6.7.3 Sediment Characterization Summary

The analytical data collected during the sediment sampling program indicated that the following major compounds were frequently detected in sediments at the Site:

VOCs:

244TM1P, 244TM2P, Toluene and Acetone;

SVOCs:

Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl

Benzylphthalate (BBZP), Di-N-Octylphthalate (DNOP),

Di-N-Butylphthalate (DNBP) and

N-Nitrosodiphenylamine (NNDPA); and

Inorganics:

Aluminum, Ammonia, Calcium, Chloride, Chromium

(VI & total), Sodium and Sulphate.

The highest concentrations of all the above compounds were generally detected in the West Ditch and decreased across the Facility.

It is to be noted that VOCs including TRCLE, 12DCE, CLC6H5, TCLEE and C2H3CL were detected at maximum concentrations at location SW-23 in the East Ditch downstream of the Facility. Downstream locations SW-25 and SW-27 also exhibit elevated concentrations of the above

VOCs. These data suggest a source other than the Facility and are also supported by groundwater data from well GW-49D (see Section 6.5).

The atmospheric fate and transport mechanisms for 244TM1P and 244TM2P are characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from sediment. There are no available data found regarding water solubility. Soil adsorption cannot be predicted due to the lack of available Koc values in literature (see Appendix K).

As discussed for test pit samples, the phthalate isomers, B2EHP, BBZP, DNBP, DNOP and NNDPA all exhibit high Koc values and will strongly adsorb to organic material in soils. Therefore, they have a very low potential for partitioning to the surface water and will be virtually immobile in the sediments. However, the migration of phthalate isomers and NNDPA may occur via sediment transport in surface water. The inorganic compounds ammonia, calcium, chloride, sodium and sulphate all exhibit high solubilities and will, therefore, exhibit a high potential for partitioning to surface water. Aluminum and chromium are considered to be virtually bound to the sediments under normal conditions (i.e. neutral pH), but their leachability from the sediment will increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds.

## 7.0 SUMMARY AND CONCLUSIONS

Based on the results of the CSA, the following summary and conclusions are made:

- 1) Historic underground utilities at the Facility are not considered to represent potential preferential routes of migration of contaminants.
- 2) The geologic units identified at the Site include in descending order of age:
  - glacial outwash;
  - glacial ice contact deposits;
  - glacial till; and
  - bedrock (fine grained sedimentary gneiss).
- The glacial ice contact deposits ( $k = 1 \times 10^{-2}$  cm/sec to  $1 \times 10^{-4}$  cm/sec) and outwash ( $k = 1 \times 10^{-1}$  cm/sec to  $1 \times 10^{-3}$  cm/sec) function as the single, principal hydrostratigraphic unit in the area of the Site. The uppermost fractured portion of the bedrock surface beneath the Site is considered part of this flow system. Below the upper fractured bedrock, minor groundwater is transmitted along small fractures and joints.
- The Site area encompasses portions of two hydrogeologic basins with the zone of regional groundwater divide separating these two basins located west and north of the Facility. East of the divide, the general groundwater flow direction is from northwest to southeast across the main part of the Facility. In the area of Plant B, groundwater flow is controlled by pumping an interceptor well system. Groundwater flow from the Facility discharges into the ditches bounding the Facility. West of the divide, the groundwater flow is directed to the west into the main portion of the regional aquifer.
- 5) Groundwater flow velocity on the Facility ranges between 100 feet to 325 feet per year. In the area west of the Facility but east of the divide,

groundwater flow velocity is approximately 10 feet/year. West of the zone of regional groundwater divide, groundwater flow velocity ranges between 10 feet to 425 feet per year.

- 6) The Site lies in both the headwaters of the Ipswich River and the Aberjona River watersheds. The surface water divide separating these two watersheds runs just west and north of the Facility, and closely parallels the groundwater divide.
- There were three areas at the Facility which exhibited evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. Materials within the test pits of the three areas were identified as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine). Organic compounds B2EHP, NNDPA and NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate were the major parameters detected in the drums and/or soil samples.
- 8) The following compounds were detected in subsurface soils across the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Butanone, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl
Benzylphthalate (BBZP), Di-n-Octylphthalate (DNBP) and
N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Ammonia, Calcium, Chromium (total), Potassium,
Sodium and Sulphate

The highest concentrations of all the above compounds were detected in the central portion of the Facility in the area of former Lake Poly (SWMU No. 14).

9) The following compounds were detected in surface waters at the Facility:

VOCs:

244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone;

SVOCs:

Bis(2-ethylhexyl)Phthalate (B2EHP),

N-Nitrosodiphenylamine (NNDPA), and Phenol; and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium

(III and VI), Copper, Iron, Sodium, Sulphate and Zinc.

The highest concentrations of 244TM1P, 244TM2P, 2-Hexanone, Acetone, NNDPA, Phenol and all the inorganics except for iron, were detected in the West Ditch. The highest concentrations of B2EHP and iron were detected in the South Ditch.

10) The following major compounds were frequently detected in sediments at the Site:

VOCs:

244TM1P, 244TM2P, Toluene and Acetone;

SVOCs:

Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl

Benzylphthalate (BBZP), Di-N-Octylphthalate (DNOP),

Di-N-Butylphthalate (DNBP) and

N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium

(VI & total), Sodium and Sulphate.

The highest concentrations of all the above compounds were generally detected in the West Ditch and decreased across the Facility.

- The presence of Toluene in surface water and TRCLE, 12DCE, CLC6H5, TCLEE and C2H3CL in surface sediments at location SW-23 in the East Ditch downstream of the Facility indicate an off-Site source.
- 12) A dense groundwater plume is seen emanating from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill area. The plume is approximately 20 feet thick near wells GW-36 and GW-42D and thins to the west to approximately eight feet thick at GW-58D approximately 1,700 feet west of the Facility.
- 13) The following major Facility-related compounds were frequently detected in groundwater at the Site:

VOCs: 244TMIP, 244TM2P, Acetone, Toluene and Bromoform;

SVOCs: Phthalate isomers, NNDPA, Phenolic Compounds; and

Inorganics: Aluminum, Ammonia, Calcium, Chromium (VI and total), Chloride, Magnesium, Potassium, Sodium and Sulphate.

The VOCs and SVOCs are mainly limited to the Facility. The inorganic compounds ammonia, chloride, chromium and sulphate are the major Facility-related parameters associated with the off-Site dense plume.

- 14) Based on the knowledge of chemicals which were directed into the central portion of the property, this area is considered to be the primary source of the inorganic plume associated with the Facility.
- 15) Three factors are believed to have had the major influence over dense contaminant migration in the aquifer: the slope of the bedrock surface; the hydraulic forces generated from recharge of the wastewater into the

- unlined pits and Lake Poly; and the dilution effects at the plume edge which control pH.
- 16) The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources: the discharge of yard and process spills and oily wastes to Lake Poly, the disposal of organic wastes to unlined pits, and the disposal of drums containing organic compounds beneath the ground surface.
- 17) In the area of monitoring well GW-49 east of the Facility, an off-Site source of organic contaminants is indicated, since no apparent correlation can be made between the Facility and the organic compounds detected in well GW-49.

# 8.0 <u>RECOMMENDATIONS</u>

Recommendations for future actions are not included as part of this CSA Phase II Field Investigations Report but will be provided as an Addendum to this report upon completion of the CSA Phase II Risk Assessment Report, currently being completed by ABB.

All of Which is Respectfully Submitted,

CONESTOGA-ROVERS & ASSOCIATES

Ed Roberts, P. Eng.

Jon Michels, B.A.

FIGURES

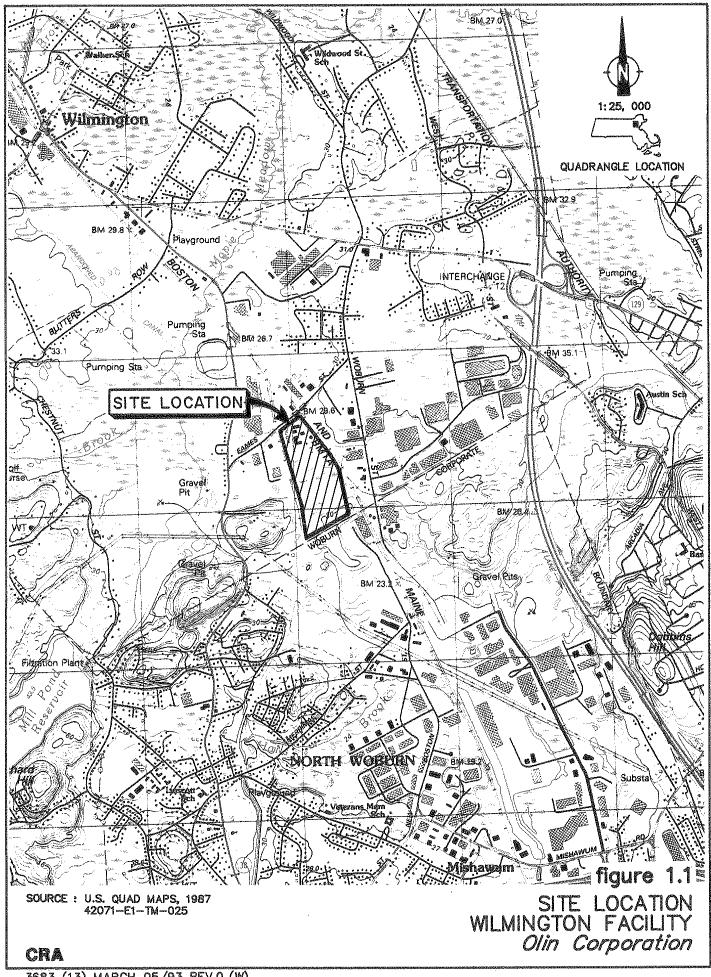
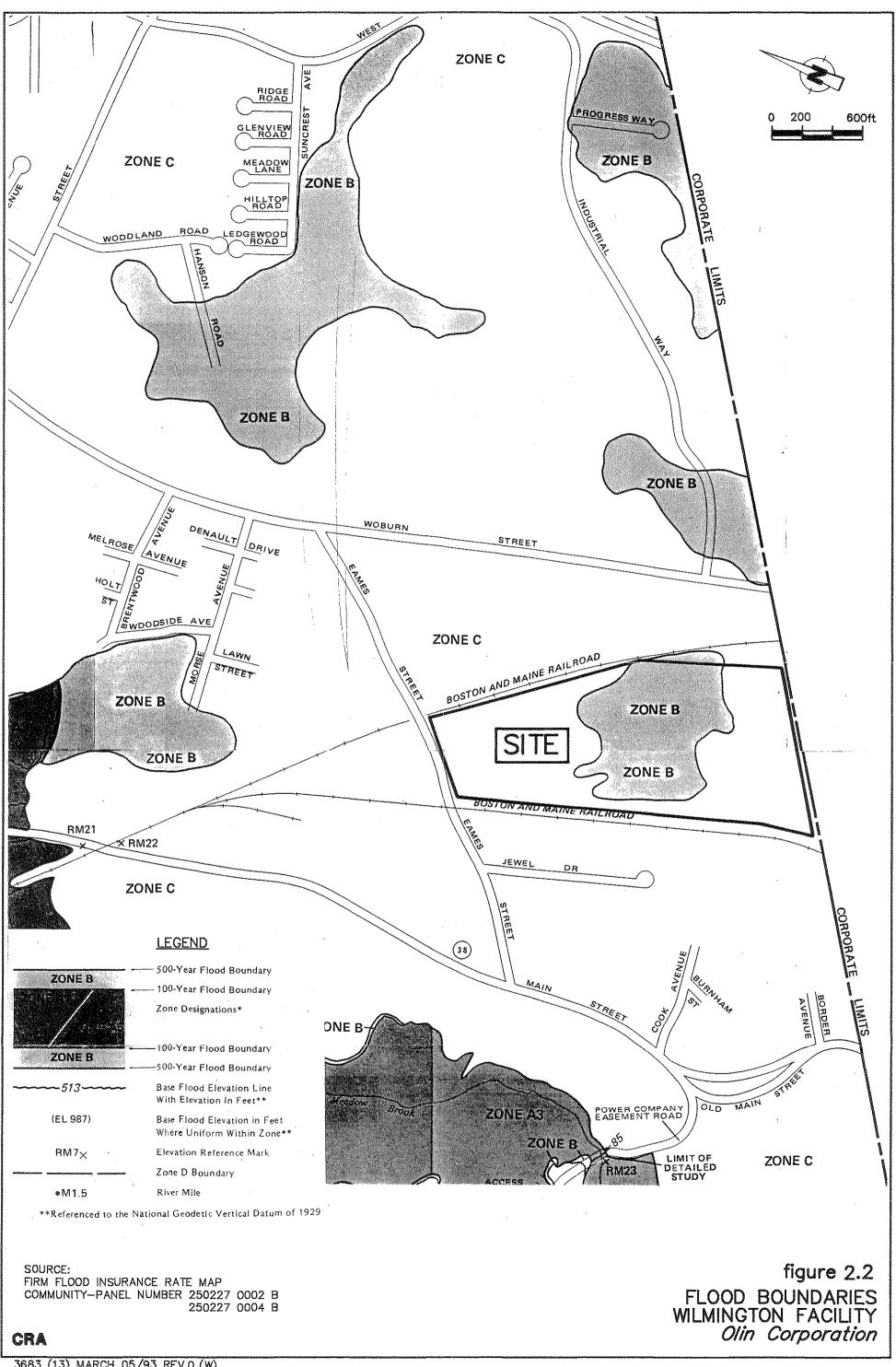
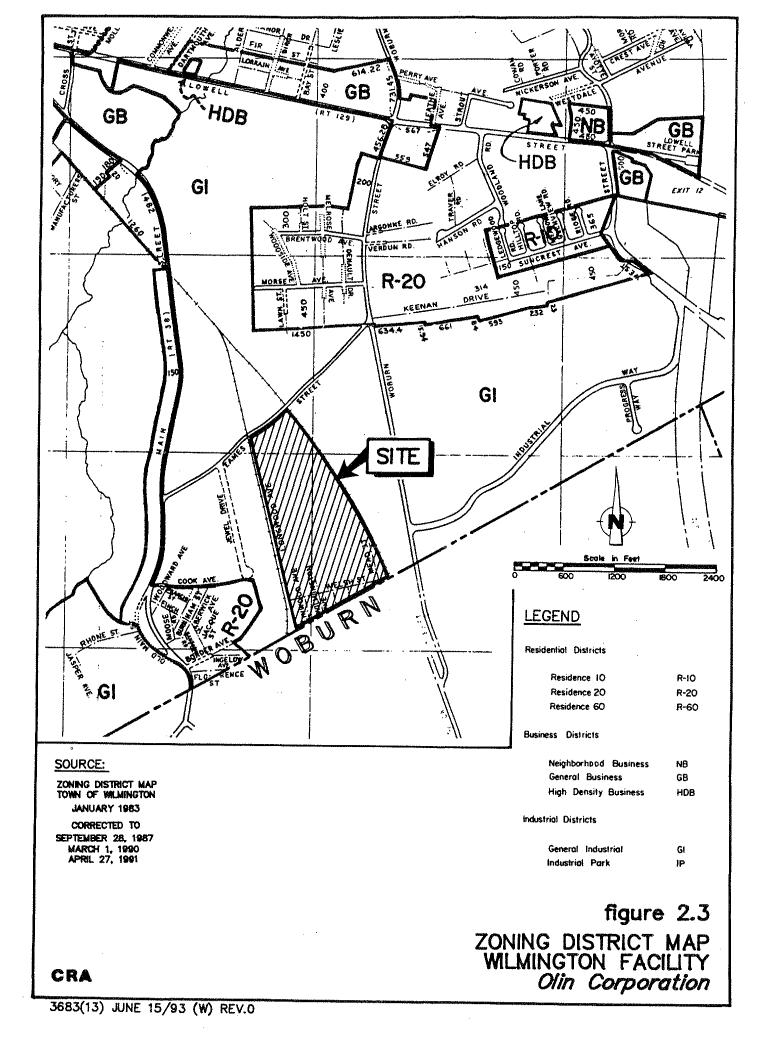


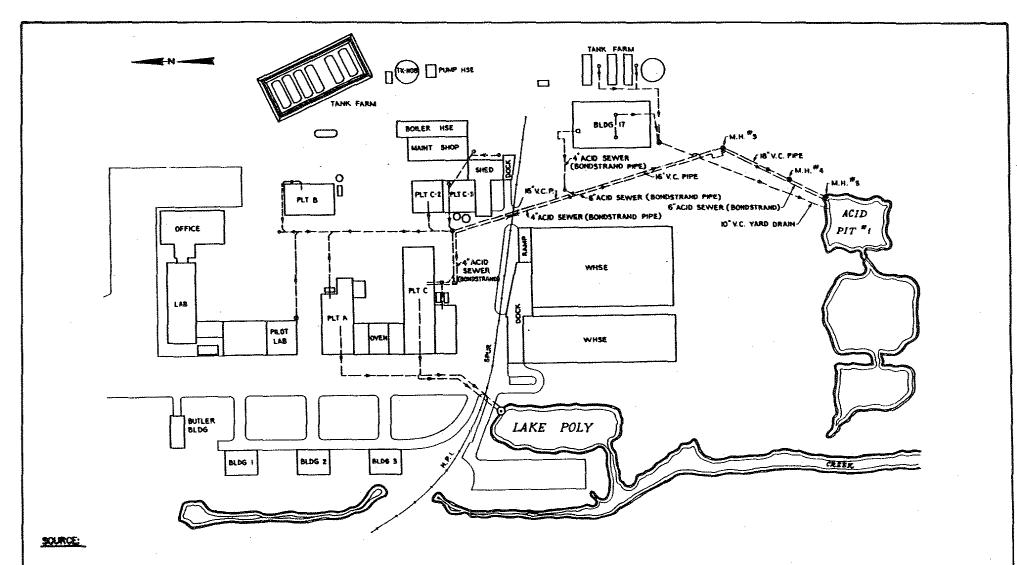




figure 2.1
1992 AERIAL PHOTOGRAPH
WILMINGTON FACILITY
Olin Corporation







TECHNICAL REPORT

WASTEWATER CHARACTERIZATION STUDY

FOR

NATIONAL POLYCHEMICALS INC.

UNDER CONTRACT 43073 17 MARCH 1970 PREPARED BY

MARINE RESEARCH LABORATORY

NEW LONDON, CONN.

Œ

RAYTHEON COMPANY

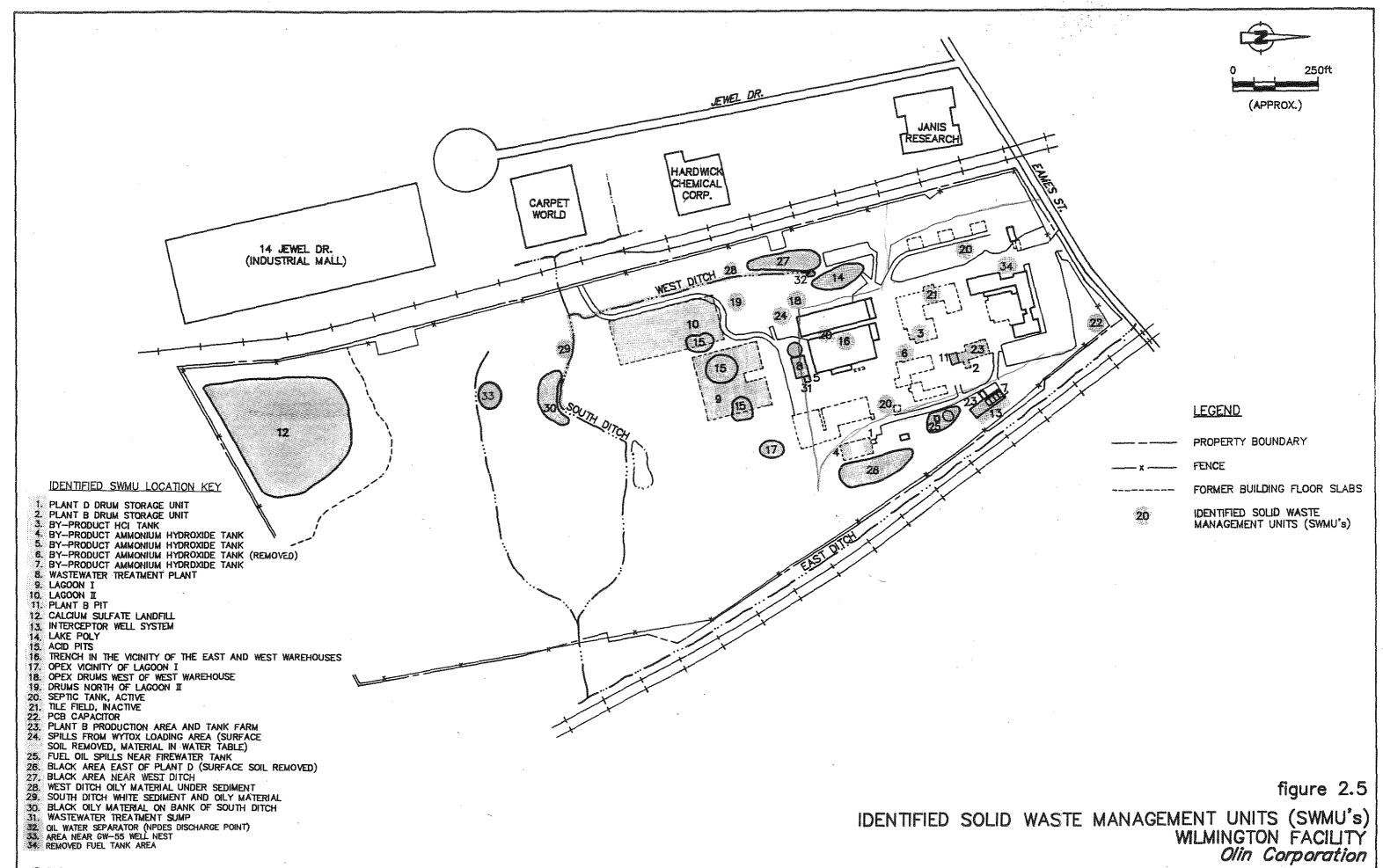
SUBMARINE SIGNAL DIVISION

PORTSMOUTH, RHODE ISLAND

figure 2.4

LOCATION OF ACID PITS AND LAKE POLY WILMINGTON FACILITY Olin Corporation

CRA



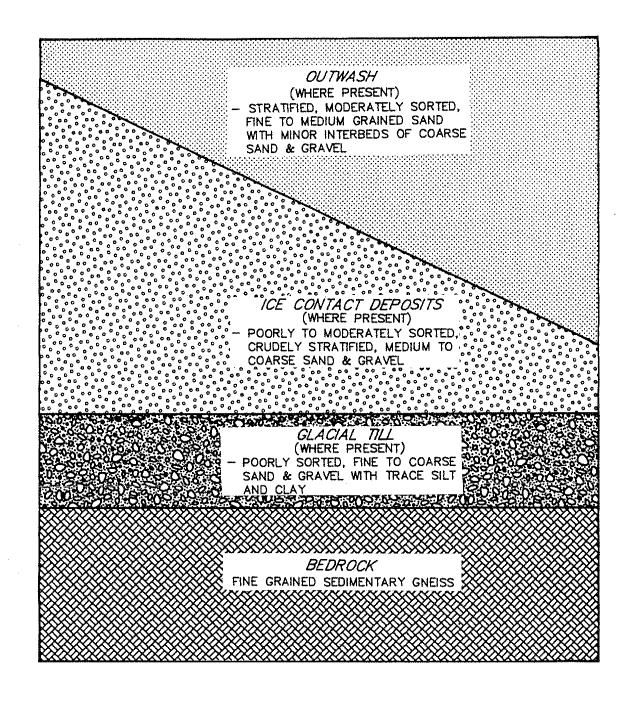
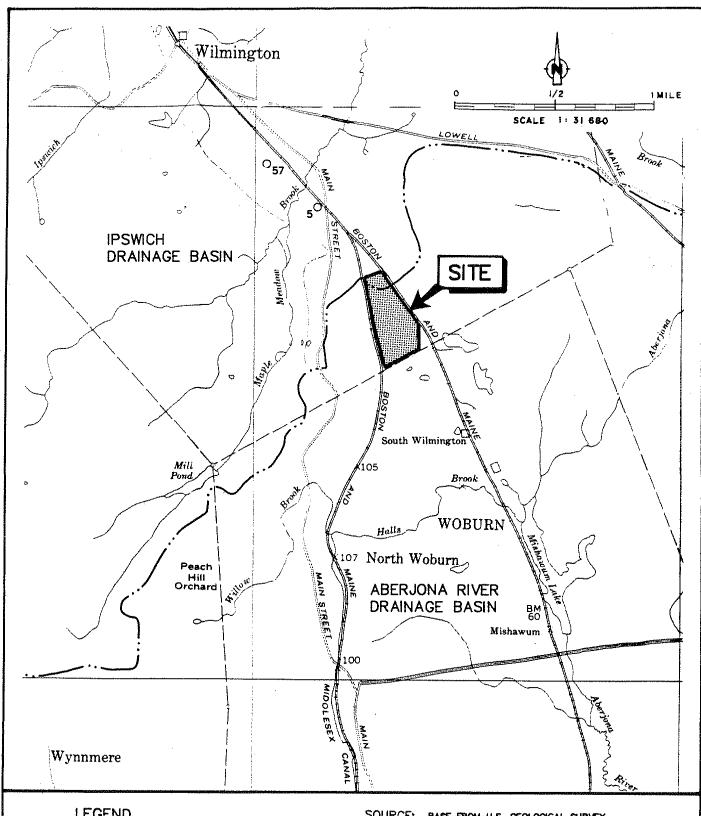


figure 3.1
GENERALIZED STRATIGRAPHIC SECTION
WILMINGTON FACILITY
Olin Corporation

CRA



**LEGEND** 

DIVIDE BETWEEN IPSWICH RIVER AND ABERJONA RIVER DRAINAGE BASINS

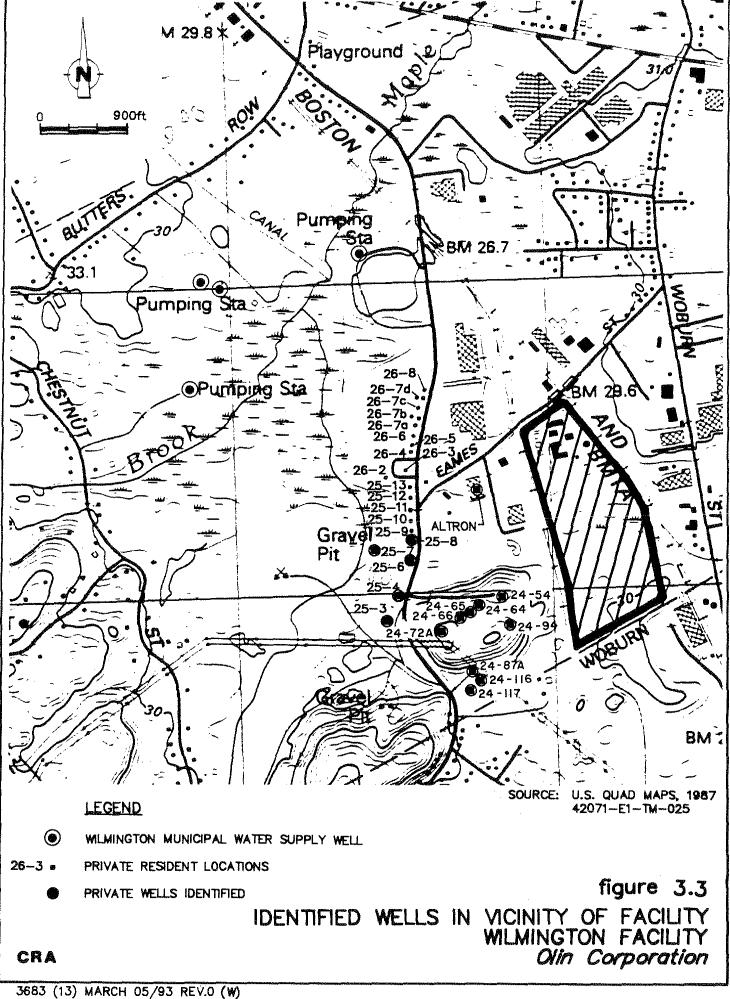
SOURCE: BASE FROM U.S. GEOLOGICAL SURVEY, SPECIAL MAPS BRANCH

MAP OF WILMINGTON-READING AREA, MASSACHUSETTS, WATER-SUPPLY PAPER 1604
PLATE 1

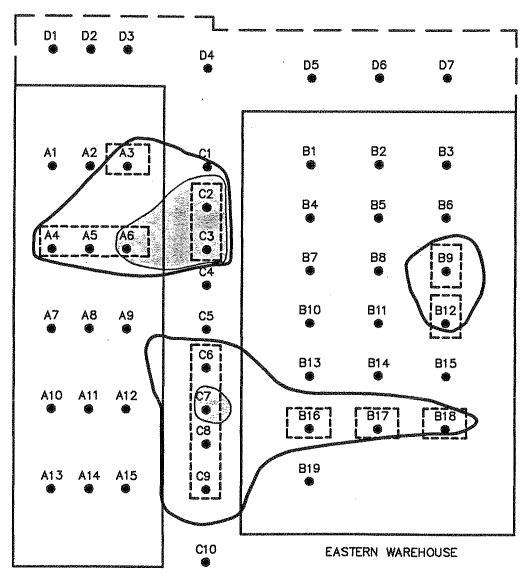
figure 3.2

REGIONAL SURFACE DRAINAGE NETWORKS WILMINGTON FACILITY Olin Corporation

CRA







WESTERN WAREHOUSE

**LEGEND** 

A13

SAMPLE POINT



TEST PIT LOCATIONS

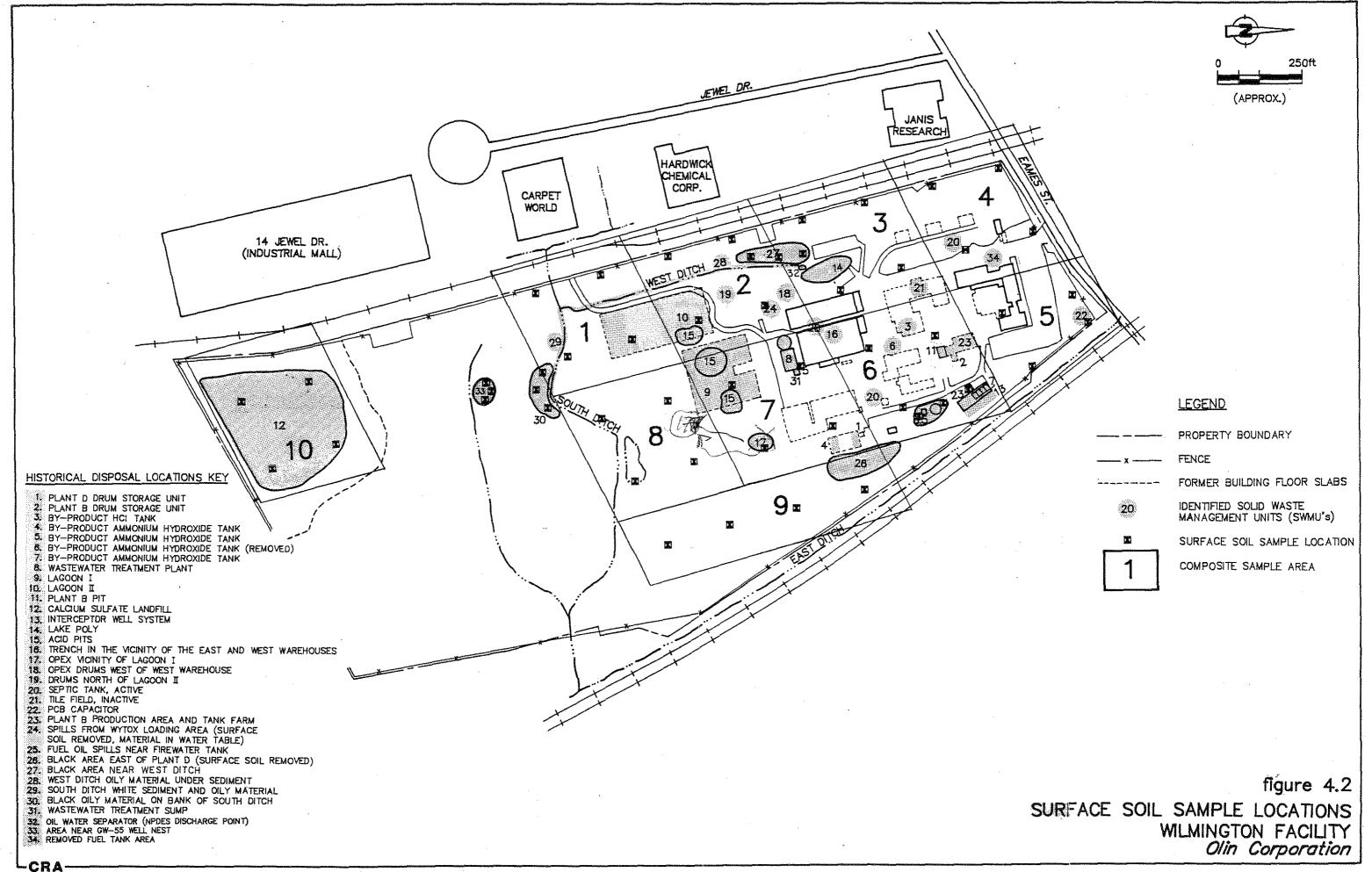


SUSPECT AREAS

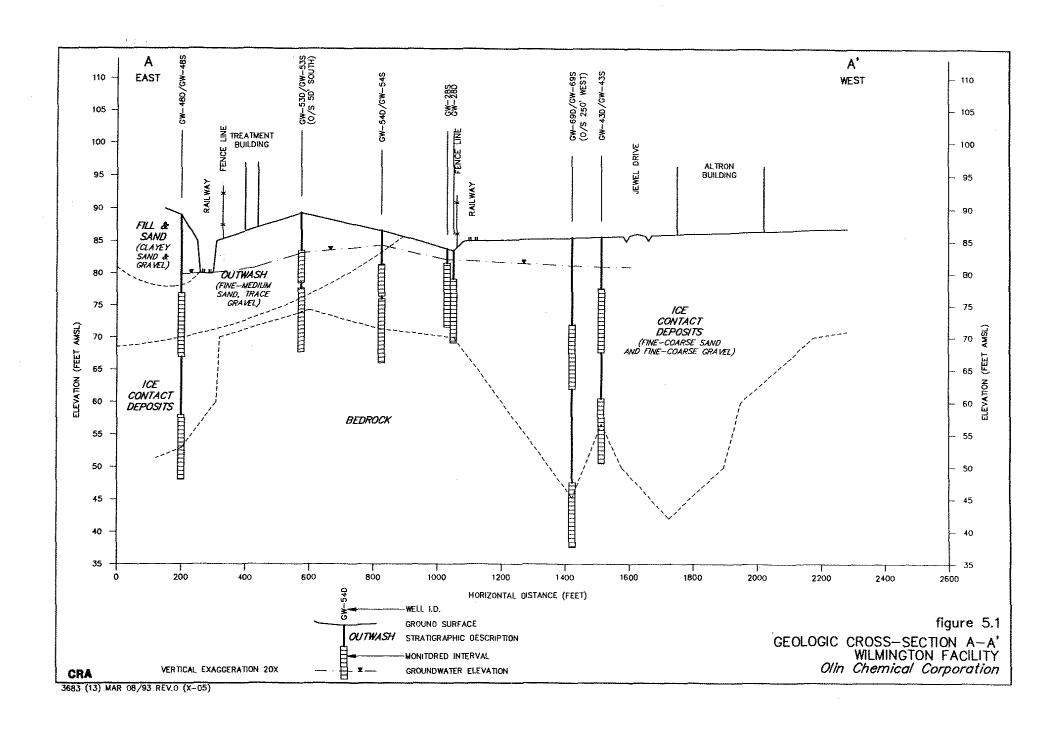
AREAS OF HIGHEST DETECTED CONCENTRATIONS figure 4.1

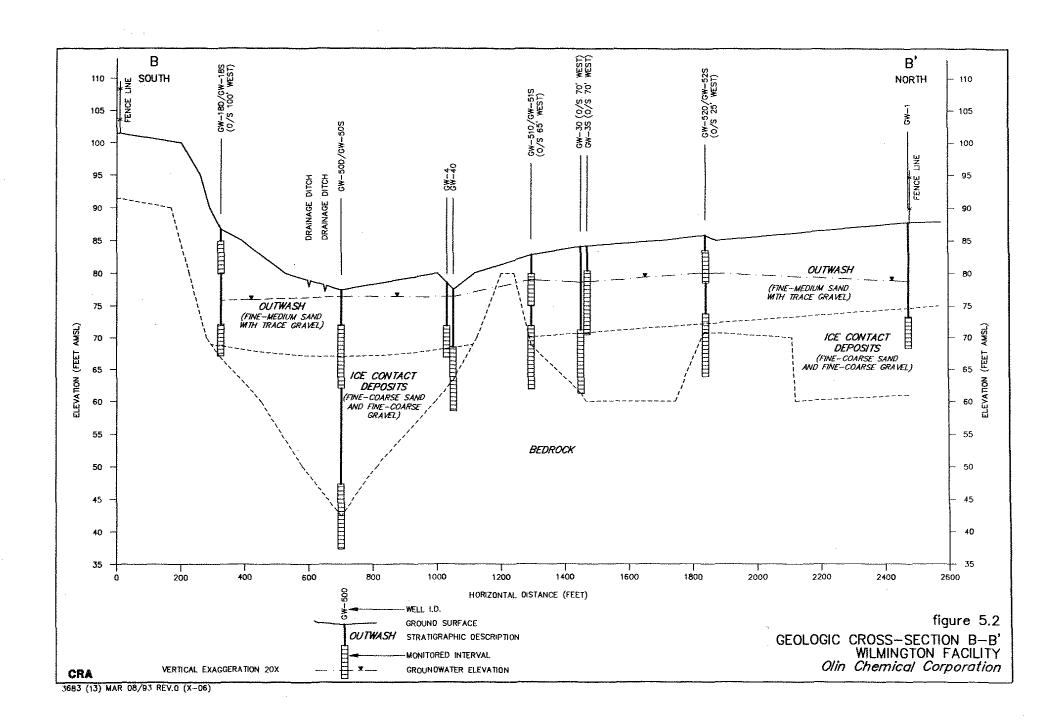
WAREHOUSE TEST PIT LOCATIONS WILMINGTON FACILITY Olin Corporation

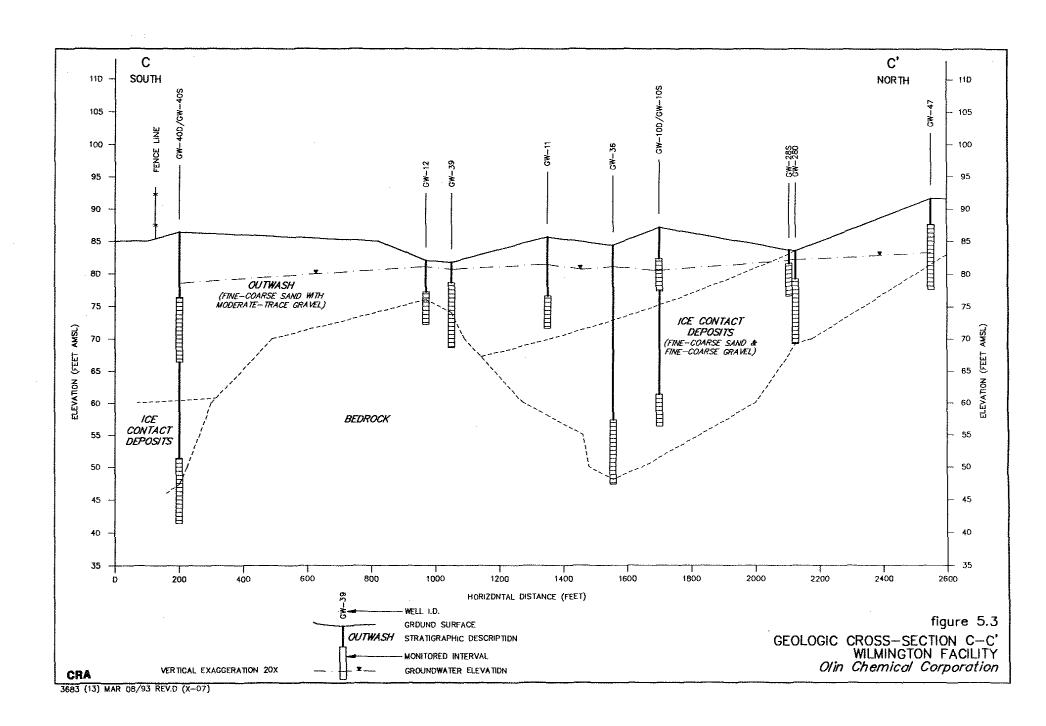
CRA

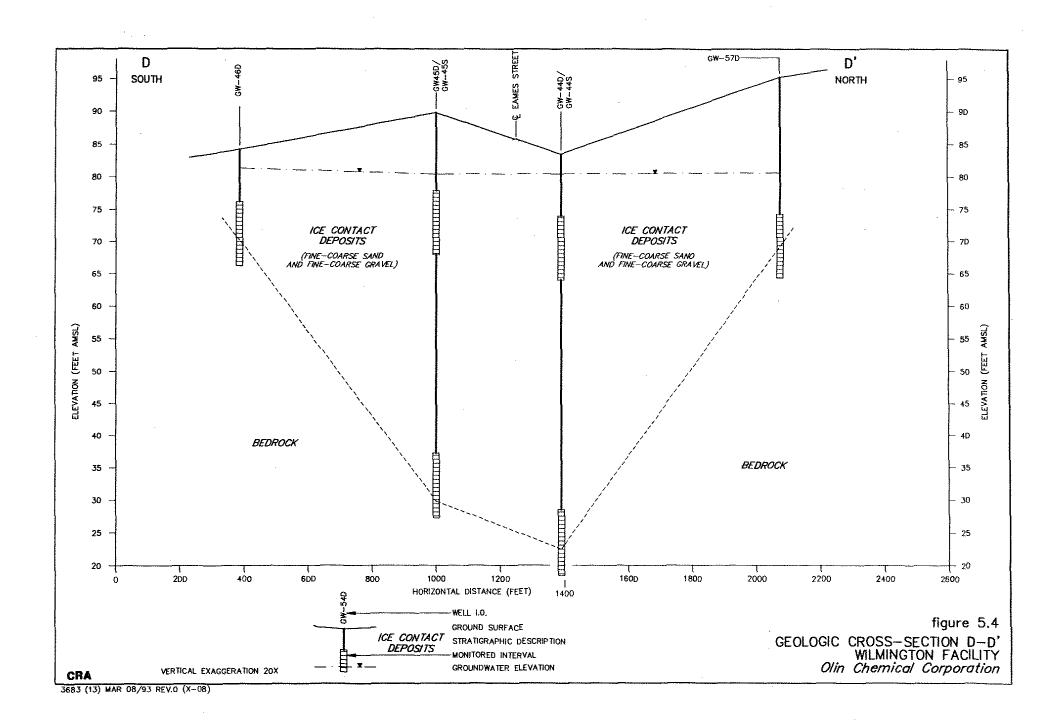


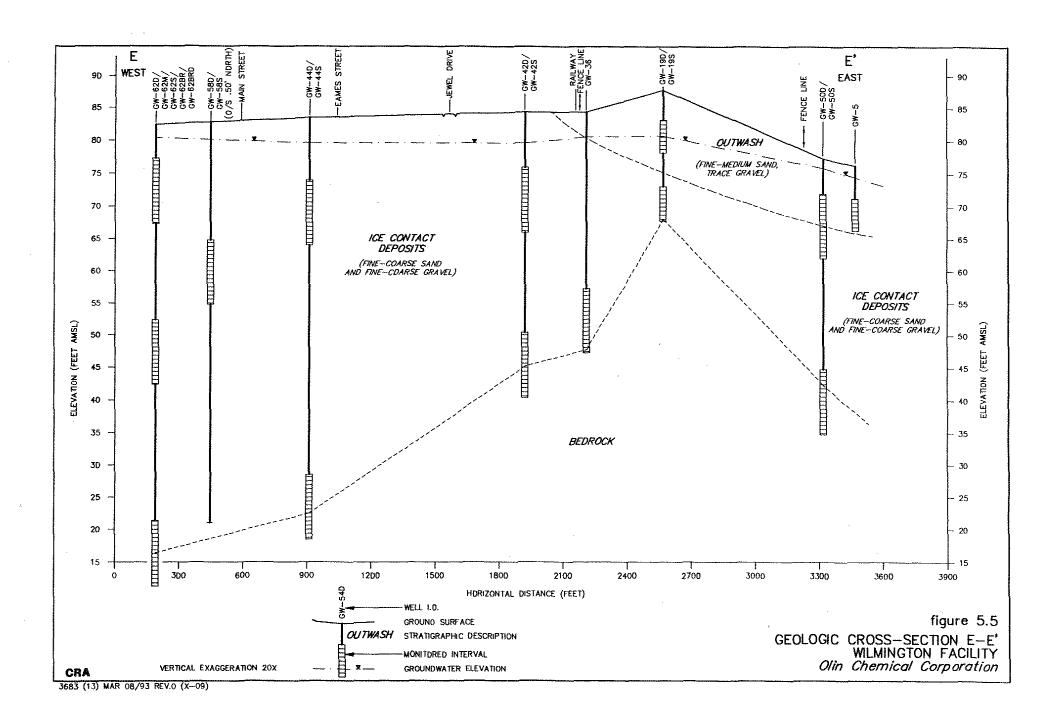
3683 (13) JUNE 11/93 REV.1 (W)

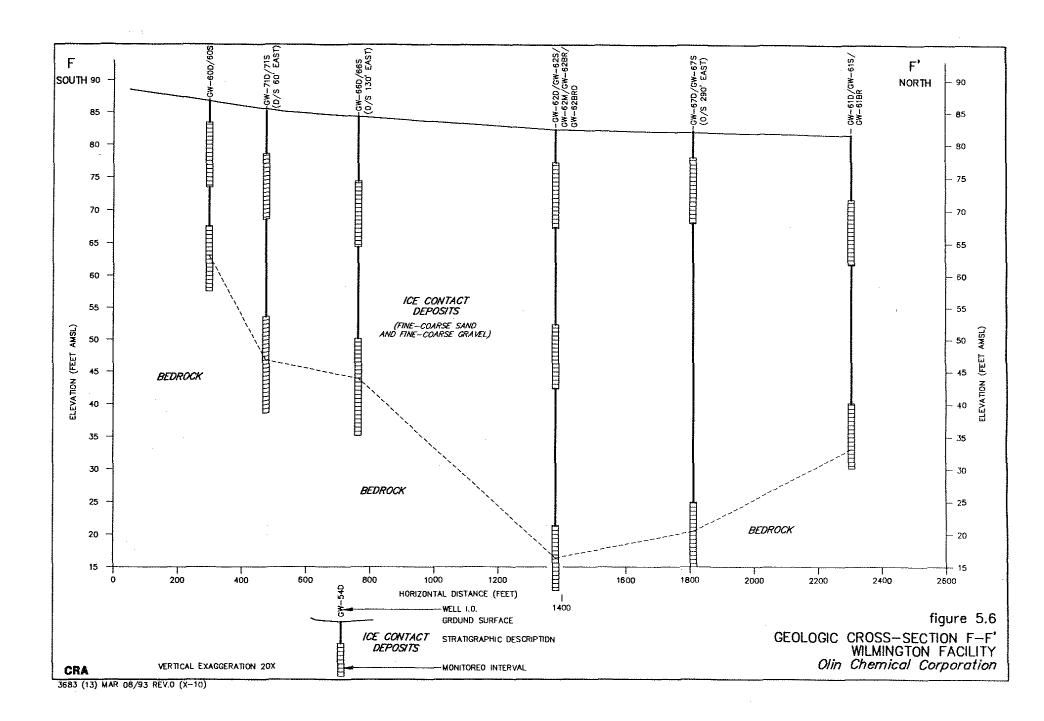












**TABLES** 

TABLE 2.1

# PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1) WILMINGTON FACILITY

| Process                                     | Raw<br>Materials   | Product  | Waste By-Products  | Process<br>Operation<br>Period |
|---|--|--|--|--------------------------------|
| Opex (Dinitrosopenta- methylenetetramine)   | Hexamethylenetetramine Sodium nitrite Hydrochloric acid Ammonia Processing oil   | Dinitrosopentamethylenetetramine (solid)                       | Sodium chloride<br>Sodium nitrate<br>Formaldehyde<br>Ammonium chloride<br>Processing oil | 1953 - 1986 (2)                |
| Kempore<br>(Azodicarbonamide)               | Hydrazine Urea sulphuric acid Sodium chlorate(3) Sodium bromide (catalyst level) | Azodicarbonamide (solid)                                       | Sodium sulphate Sulphuric acid Urea Sodium chloride Ammonium sulphate Sodium bromide     | 1956 - 1986 (2)                |
| Hydrazine(4)                                | Urea<br>Chlorine<br>Sodium hydroxide<br>Sulphuric acid                           | Hydrazine and Semicarbazide solution                           | Sodium sulphate Sodium chloride Ammonium sulphate  | 1963 - 1970                    |
| Kempore Dispersions                         | Azodicarbonamide<br>Dioctyl phthalate  | 50 percent dispersion of Azodicarbonamide in Dioctyl Phthalate | None   | 1960 - 1986 (2)                |
| Wytox 312<br>(trisnonylphenyl<br>phosphite) | Nonyl phenol<br>Phorphorus trichloride   | Trisnonylphenyl phosphite (liquid)                             | None (HCl scrubbed in water)   | 1965 - 1986 (2)                |
| Actafoam R-3                                | 2-ethylhexoic acid<br>Zinc oxide<br>Dioctyl phthalate<br>Potassium oleate        | Liquid Azodicarbonamide activitor                              | None   | 1963 - 1986 (2)                |
| Wytox PAP (Alkylated phenol) CRA 3663 (13)  | Nonyl phenol<br>Dinonyl phenol<br>Formaldehyde                                   | Liquid Alkylated phenol  | None .   | 1971 - 1986 (2)                |

TABLE 2.1

# PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1) WILMINGTON FACILITY

| Process   | Raw<br>Materials  | Product                              | Waste By-Products   | Process<br>Operation<br>Period |
|---|---|--------------------------------------|---|--------------------------------|
| Nitropore 5 PT (5)<br>(5-Phenyltetrazole)                           | Benzonitrile Sodium azide Sodium nitrite Ammonium chloride Hydrochloric acid Dimethyl Formamide | 5-phenyltetrazole (solid)            | Sodium chloride<br>Dimethyl Formamide<br>Sodium nitrate<br>Benzonitrile                 | 1 <b>96</b> 5 - 1975           |
| Nitropore OT<br>(4,4'oxybisbenzenedisulfonyl-<br>hydrazide)         | Diphenyl oxide<br>Chlorosulfonic acid<br>Hydrazine<br>Ammonia                                   | 4,4'oxybisbenzenedisulfonylhydrazide | Sulphuric acid<br>Ammonium chloride<br>Hydrochloric acid scrubbed<br>in water and solid | 196 <b>9</b> - 1986 (2)        |
| Wytox ADP<br>(Dioctyl Diphenylamine)                                | Diphenylamine<br>Diisobutylene<br>Aluminum chloride<br>Sodium hydroxide                         | Dioctyldiphenylamine                 | Aluminum hydroxide<br>Sodium hydroxide  | 196 <b>2</b> - 1986 (2)        |
| Phenolic and Urea<br>Formaldehyde Resins                            | Phenol<br>Urea<br>Formaldehyde  | Solid and liquid resins              | Phenol<br>Formaldehyde  | 1 <b>96</b> 1 - 1967           |
| Phthalate Plasticizers<br>(Dioctyl phthalate,<br>dibutyl phthalate) | Phthalic anhydride<br>2-ethylhexanol<br>Butyl alcohol   | Liquid plasticizers                  | None  | 1955 - 1961                    |
| Witrol N<br>(N-Nitrosodiphenylamine)                                | Diphenylamine<br>Sodium nitrite<br>Sulphuric acid   | N-Nitrosodiphenylamine (solid)       | Sodium nitrite<br>Sodium sulphate   | 1 <b>96</b> 5 - 1967           |

### TABLE 2.1

# PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1) WILMINGTON FACILITY

| Process  | Raw<br>Materials   | Product | Waste By-Products                         | Process<br>Operation<br>Period |
|----------|--|---------|---|--------------------------------|
| Coatings | Bentone Santocel Ufamite MM 67 Toluene Butylacetate Acrylic Resins Maleic Anhydride Glycerine Fatty Amines Silicone Monoethanolamine |         | Compounded on a batch basis with no waste | Various Times                  |

### Notes:

- (1) Table 2.1 was compiled from documents provided by Stepan in the sale of the Facility to Olin Corporation and an August 21, 1969 Badger Company Report, Pollution Control Study for National Polychemicals Inc. at Wilmington, MA.
- (2) Process operations ending in 1986 were assumed to be in operation until this time based on a 1982 Olin Corporation specialty polymer additives brochure.
- (3) Up to 1967, sodium dichromate was used in the process instead of sodium chlorate. The by-product waste contained chrome sulphate instead of sodium chloride and sodium sulphate.
- (4) This process was shut down in the fall of 1970 with hydrazine then purchased from Olin Corporation.
- (5) Limited quantities, 24,000 lb/yr.

### TABLE 2.2

# IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMUs) WILMINGTON FACILITY

| Item         | Description of Identified SWMU   |
|--------------|--|
| 1.           | Plant D Drum Storage Unit  |
| 2.           | Plant B Drum Storage Unit  |
| 3.           | By-Product HCl Tank  |
| 4.           | By-Product Ammonium Hydroxide Tank   |
| 5.           | By-Product Ammonium Hydroxide Tank   |
| 6.           | By-Product Ammonium Hydroxide Tank (Removed)                                   |
| <i>7</i> .   | By-Product Ammonium Hydroxide Tank   |
| 8.           | Wastewater Treatment Plant   |
| 9.           | Lagoon I   |
| 10.          | Lagoon II  |
| 11.          | Plant B pit  |
| 12.          | Calcium Sulphate Landfill  |
| 13.          | Interceptor Well System  |
| 14.          | Lake Poly  |
| 15.          | Acid Pits  |
| 16.          | Trench in the vicinity of the East and West Warehouses                         |
| 1 <i>7</i> . | Opex Vicinity of Lagoon I  |
| 18.          | Opex Drums West of West Warehouse  |
| 19.          | Drums North of Lagoon II   |
| 20.          | Septic Tank, Active  |
| 21.          | Tile Field, Inactive   |
| 22.          | PCB Capacitor  |
| 23.          | Plant B Production Area and Tank Farm  |
| 24.          | Spills from Wytox Loading Area (surface soil removed, material in water table) |
| 25.          | Fuel Oil Spills near Firewater Tank  |
| 26.          | Black Area East of Plant D (surface soil removed)                              |
| 27.          | Black Area Near West Ditch   |
| 28.          | West Ditch Oily Material Under Sediment.                                       |
| 29.          | South Ditch White Sediment and Oily Material                                   |
| 30.          | Black Oily Material on Bank of South Ditch                                     |
| 31.          | Wastewater Treatment Sump  |
| 32.          | Oil Water Separator (NPDES Discharge Point)                                    |
| 33.          | Area Near GW-55 Well Nest  |
| 34.          | Removed Fuel Tank Area   |

TABLE 3.1

SUMMARY OF WILMINGTON TOWN WELLS WEST OF FACILITY

WILMINGTON FACILITY

|                 |      | Maximum I | Design Yeild | Average Pu | mping Rate  | Screened<br>Interval |
|-----------------|------|-----------|--------------|------------|-------------|----------------------|
| Well Location   |      | MGD       | <i>GPM</i>   | MGD        | GPM         | ft bgs               |
| Chestnut Street |      | 1.4       | 950          | 0.5        | 350         | 45-55                |
| Town Park       |      | 0.5       | 350          | 0.2        | 180         | 29-39                |
| Butters Row #1  |      | 1.3       | 900          | 0.7        | <b>4</b> 50 | 39-51.5              |
| Butters Row #2  |      | 1.4       | 950          | 0.9        | 650         | 36-46                |
| T               | otal | 4.6       | 3,150        | 2.3        | 1,630       |                      |

ft bgs feet below ground surface MGD million gallons per day GPM gallons per minute

(1) Source: Aquifer Protection Study, Town of Wilmington, June 1990, IEP, INC.

TABLE 3.2

PRIVATE WELL SUMMARY IN VICINITY OF FACILITY
WILMINGTON FACILITY

| Plot | Parcel      | Location    | Water    | Unit                  | Approximate Date Well   |
|------|-------------|-------------|----------|-----------------------|-------------------------|
| #    | #           |             | Source   |                       | Connected to Town Water |
| 24   | 54          | Cooke Ave.  | Well     | Bedrock               | NA                      |
| 24   | 64          | Cooke Ave.  | Well     | Bedrock               | NA                      |
| 24   | 65          | Cooke Ave.  | Well     | Bedrock               | NA                      |
| 24   | 66          | Cooke Ave.  | Well     | Bedrock               | NA "                    |
| 24   | 72A         | Cooke Ave.  | Well     | Bedrock               | NA                      |
| 24   | 94          | Cooke Ave.  | Well     | Bedrock               | NA                      |
| 24   | 8Z <b>A</b> | Border Ave. | Well     | Bedrock               | NA                      |
| 24   | (116)       | Border Ave. | Well     | Bedrock               | NA                      |
| 24   | 117         | Border Ave. | Well     | Bedrock               | NA                      |
| 25   | 3 🐔         | Main St.    | Well (1) | Shallow Sand & Gravel | NA                      |
| 25   | 4           | Main St.    | Well (1) | Shallow Sand & Gravel | NA                      |
| 25   | 6 sum       | Main St.    | Well (1) | Shallow Sand & Gravel | NA                      |
| 25   | 71          | Main St.    | Well (1) | Shallow Sand & Gravel | NA                      |
| 25   | 8-/         | Main St.    | Well (1) | Shallow Sand & Gravel | NA                      |
| 25   | 9           | Main St.    | Town     | •••                   | 1983                    |
| 25   | 10          | Main St.    | Town     | we det                | 1984                    |
| 25   | 11          | Main St.    | Town     | *******               | 1959                    |
| 25   | (12)        | Main St.    | Town     |                       | ~1959                   |
| 25   | 13          | Main St.    | Town     | ge-re-                | ~1959                   |
| 26   | 2           | Main St.    | Town     | <del>de m</del>       | 1957                    |
| 26   | 3           | Main St.    | Town     | ·-                    | 1970-73                 |
| 26   | 4           | Main St.    | Town     | gr-ne-                | 1957-59                 |
| 26   | 5           | Main St.    | Town     |                       | 1959                    |
| 26   | 6           | Main St.    | Town     | ***                   | 195 <i>7</i>            |
| 26   | <i>7</i> a  | Main St.    | Town     |                       | 1973                    |
| 26   | <i>7</i> b  | Main St.    | Town     | <del></del>           | 1970-73                 |
| 26   | 7c          | Main St.    | Town     | <del></del>           | 1970-73                 |
| 26   | 7d          | Main St.    | Town     | No.                   | 19 <b>7</b> 3           |
| 26   | 8           | Main St.    | Town     | ***                   | 1957                    |

(1) According to information provided by Olin, residents use bottled water or pretreat water for drinking.

NA Not applicable.

# CSA FIELD ACTIVITIES SUMMARY WILMINGTON FACILITY

Activity

Dates

Residential Well Sampling

Oct. 90, Sept. 91.

Aerial Photo/Topographic Surveys

Dec. 90, Dec. 91.

Magnetometer Surveys

Dec. 90, Jan. 91.

Monitoring Well Installations

June 91, July 91, Dec. 91, Jan. 92, Feb. 92, April 92,

May 92, July 92, Aug. 92, Nov. 92, Dec. 92,

Jan. 93, Mar. 93, April 93, May 93.

Investigative Soil Borings

June 91, Feb. 92.

Slug Testing/Pump Testing

July 91, Feb. 92, Jan. 93.

Surface Soil Sampling

July 91, May 93.

Groundwater Sampling

Aug. 91, Dec. 91, Feb. 92, May 92, Aug. 92, Nov. 92, Dec. 92, Jan. 93, April 93, May 93.

Water Level Monitoring

Sept. 91, Feb. 92, July 92, Aug. 92, Sept. 92,

Jan. 93, April 93.

Surface Water/Sediment Sampling

Oct. 91, Dec. 91, Aug. 92, Sept. 92, Nov. 92,

Dec. 92, Jan. 93, Mar. 93, April 93.

Seismic Refraction Surveys

Oct. 91, Feb. 92.

Test Pit Excavations

Oct. 91, July 92.

Soil Gas Survey

Feb. 92.

Field Reconnaissance/Geologic Mapping

Feb. 92.

Piezometer/Staff Gauge Installations

July 92, Oct. 92.

EM/Temperature Logging

Aug. 92, Dec. 92, Jan. 93.

Town Well Sampling

Sept. 92.

TABLE 4.2

TEST PIT EXCAVATION SAMPLE SUMMARY WILMINGTON, FACILITY

| Date Sampled<br>(mm/dd/yy) | Sample<br>ID | Test Pit<br>Location | Matrix | Sample<br>Description   |
|----------------------------|--------------|----------------------|--------|---|
| 10/02/91                   | S-01-TP-1    | TP-1                 | Soil   | Black, sandy silt, slight odor  |
| 10/02/91                   | DS-02-TP-6   | TP-6                 | Drum - | Dark gray greasy compound   |
| 10/03/91                   | DS-03-TP-8   | TP-8                 | Drum - | Milky white viscous compound  |
| 10/03/91                   | DS-04-TP-8   | TP-8                 | Drum - | Green-Blue granular compound with strong OVA reading (>200 ppm)                                   |
| 10/03/91                   | DS-04-TP-8   | TP-8                 | Drum   | Duplicate of DS-04-TP-8   |
| 10/07/91                   | S-06-TP-19   | TP-19                | Soil   | Black, silty sand with strong OVA reading (270 ppm)   |
| 10/08/91                   | DS-07-TP-21  | TP-21                | Drum   | Brittle black resin with strong OVA reading (>520 ppm)  |
| 10/08/91                   | S-08-TP-21   | TP-21                | Soil   | Milky white and blue gray<br>compounds mixed with sandy<br>soil, moderate OVA reading<br>(82 ppm) |

TABLE 4.3

### SUMMARY OF HNU SCREENING WAREHOUSE TEST PITS WILMINGTON, FACILITY

| Test Pit<br>Location                           | Sample<br>Depth<br>((ft bgs)         | Date<br>Sampled<br>(mm/dd/yy)                            | HNU<br>Reading<br>(ppm)         | Sample<br>Description   |
|--|--------------------------------------|--|---------------------------------|---|
| Eastern Warehouse                              |                                      |  |                                 |   |
| WHTP-1<br>WHTP-2<br>WHTP-3<br>WHTP-4<br>WHTP-5 | 12.0<br>12.0<br>11.0<br>10.5<br>10.0 | 07/29/92<br>07/28/92<br>07/28/92<br>07/28/92<br>07/28/92 | 0.0<br>0.0<br>0.0<br>0.0<br>0.0 | Sand and Gravel<br>Sand and Gravel<br>Sand and Gravel<br>Sand and Gravel<br>Sand and Gravel |
| Between Warehouses                             |                                      |  |                                 |   |
| WHTP-6<br>WHTP-7                               | 9.0<br>9.0                           | 07/29/92<br>07/29/92                                     | 0.0<br>0.0                      | Gravel<br>Gravel  |
| Western Warehouse                              |                                      |  | •                               |   |
| WHTP-8<br>WHTP-9                               | 10.0<br>1.0                          | 07/30/92<br>07/30/92                                     | 0.0<br>0.0                      | Sand and Gravel<br>Sand and Gravel  |

### Notes:

ft bgs -ppm feet below ground surface parts per million

TABLE 4.4

### MONITORING WELL COMPLETION DETAILS SUMMARY WILMINGTON FACILITY

|                         |                              |                                |                                      | Monitored (Sc          | reened) Interval | Sand Pa                | ck Interval    |                          | Top of Bedrock |                |
|-------------------------|------------------------------|--------------------------------|--------------------------------------|------------------------|------------------|------------------------|----------------|--------------------------|----------------|----------------|
| Monitaring<br>Well I.D. | Date Completed<br>(mm/dd/yy) | Ground Elevation<br>(ft. AMSL) | Top of Casing<br>Elevation (ft AM5L) | Elevation<br>(ft AMSL) | Depth (ft bgs)   | Elevation<br>(ft AMSL) | Depth (ft bgs) | Well Materials           | Depth (ft bgs) | Elev (ft AMSL) |
| GW Monitorin            | g Wells                      |                                |                                      |                        |                  |                        |                |                          |                |                |
| GW-1                    | 10/26/77                     | 87.8                           | 88.89                                | 73.3-68.3              | 14.5-19.5        | 87.8-67.8              | 0-20.0         | 1.5°Ø PVC casing/screen  | NA             | NA             |
| GW-2*                   | 11/01/77                     | 87.6                           | 88.10                                | 78,1-73.1              | 9.5-14.5         | 87.6-72.6              | 0-15.0         | 1.5°Ø PVC casing/screen  | NA             | NΛ             |
| GW-3S                   | 11/01/77                     | 85.4                           | 86.69                                | 75.4-70.4              | 10.0-15.0        | 85.4-70.4              | 0-15.0         | 1.5"@ PVC casing/screen  | NA             | NΛ             |
| GW-3D                   | 06/25/86                     | 84.1                           | 85.23                                | 71.2-61.2              | 12.9-22.9        | ?-61.2                 | 7-22.9         | 1.5°Ø PVC casing/screen  | 22.9           | 61.2           |
| GW-4                    | 10/31/77                     | 79,8                           | 82.12                                | 71.8-66.8              | 8.0-13.0         | 79,8-66.8              | 0-13.0         | 1.5"Ø PVC casing/screen  | NA             | NΛ             |
| GW-4D                   | 06/21/91                     | 77.5                           | 79.23                                | 68.5-58.5              | 9.0-19.0         | 70.5-56.5              | 2.0-21.0       | 2" Ø PVC casing/screen   | 14.2           | 63.3           |
| GW-5                    | 10/28/77                     | 76.3                           | 79.46                                | 71.3-66.3              | 5.0-10.0         | 76.3-66.3              | 0-10.0         | 1.5"Ø PVC casing/screen  | NA             | NΑ             |
| GW-6S                   | 10/28/77                     | 87.2                           | 88.72                                | 79.0-74.0              | 8.2-13.2         | 87.2-72.2              | 0-15.0         | 1.5"Ø PVC casing/screen  | NA             | NA             |
| GW-6D                   | 06/17/86                     | 87.9                           | 89.43                                | 70.5-60.5              | 17.4-27.4        | ?-60.5                 | ?-27.4         | 1.5"Ø PVC casing/screen  | 27.4           | 60.5           |
| GW-7                    | 10/27/77                     | 82.7                           | 84.81                                | 74.2-69.2              | 8.5-13.5         | 82.7-68.7              | 0-14.0         | 1.5"Ø PVC casing/screen  | NA             | NA             |
| GW-8                    | 10/28/77                     | 77.8                           | 83.19                                | 74.6-69.6              | 3.2-8.2          | 77.8-67.8              | 0-10.0         | 1.5"Ø PVC casing/screen  | NA             | NA             |
| GW-10S                  | 11/02/77                     | 87.1                           | 89.61                                | 82.3-77.3              | 4.8-9.8          | 87.1-77.1              | 0-10.0         | 1.5"Ø PVC casing/screen  | NΑ             | NA             |
| GW-10D                  | 07/11/86                     | 83,5                           | 84.19                                | 66.3-56.3              | 17.2-27.2        | ?-56.3                 | ?-27.2         | 1.5"Ø PVC casing/screen  | 27.2           | 56.3           |
| GW-11                   | 10/31/77                     | 85.6                           | 87.22                                | 76.6-71.6              | 9.0-14.0         | 85.6-70.6              | 0-15.0         | 1.5°Ø PVC casing /screen | NA             | NA             |
| GW-12                   | 11/02/77                     | 82.0                           | 84.62                                | 77.2-72.2              | 4.8-9.8          | 82.0-72.0              | 0-10.0         | 1.5"Ø PVC casing/screen  | NA             | NA             |
| GW-13                   | 12/03/80                     | 89.0                           | 90.62                                | 75.5-70.5              | 13.5-18.5        | 76.5-70.5              | 12.5-18.5      | 3"ØPVC casing/screen     | NA             | NA             |
| GW-14                   | 12/04/80                     | 87.4                           | 88.70                                | 79.9-74.9              | 7.5-12.5         | 80.9-74.9              | 6.5-12.5       | 4"OPVC casing/screen     | NA             | NA             |
| GW-15                   | 12/07/80                     | 88.7                           | 90.07                                | 74.2-69.2              | 14.5-19.5        | 75.2-69.2              | 13.5-19.5      | 3"ØPVC casing/screen     | NA             | NA             |
| GW-16                   | 12/04/80                     | 90.1                           | 91.18                                | 80.1-75.1              | 10.0-15.0        | 81,1-75.1              | 9.0-15.0       | 3"ØPVC casing/screen     | NA             | NA             |
| GW-175                  | 03/04/81                     | 79.7                           | 82.10                                | 76.7-71.7              | 3.0-8.0          | 77.7-71.7              | 2.0-8.0        | 2"ØPVC casing/screen     | NA             | NA             |
| GW-17D                  | 03/03/81                     | 79.6                           | 81.46                                | 72.6-67.6              | 7.0-12.0         | 72.6-67.6              | 7.0-12.0       | 2"ØPVC casing/screen     | 13.0           | 66.6           |
| GW-18S                  | 02/25/81                     | 86.7                           | 89.64                                | 86.7-76.7              | 5.0-10.0         | 83.7-76.7              | 3.0-10.0       | 2°ØPVC casing/screen     | NA.            | NA             |
| GW18D                   | 02/24/81                     | 86.7                           | 88.96                                | 72.2-67.2              | 14.5-19.5        | 76.7-66.7              | 10.0-20.0      | 2"ØPVC casing/screen     | 19.9           | 66.8           |
| GW-19S                  | 02/12/81                     | 88.2                           | 89,88                                | 83.2-78.2              | 5.0-10.0         | 84.7-78.2              | 3.5-10.0       | 2"ØPVC casing /screen    | NΑ             | NA.            |
| GW-19D                  | 02/09/81                     | 87.8                           | 89.78                                | 73.1-68.1              | 14.7-19.7        | 77.8-67.8              | 10.0-20.0      | 2"ØPVC casing/screen     | 20.0           | 67.8           |
| GW-20                   | 02/26/81                     | 83.4                           | 85.60                                | 73.7-68.7              | 9.7-14.7         | 75.4-68.4              | 8.0-15.0       | 2"ØPVC casing/screen     | 15.0           | 68.4           |
| GW-21S                  | 06/25/86                     | 89.6                           | 90.90                                | 80.2-70.2              | 9.4-19.4         | ?-70.2                 | ? - 19.4       | 15"OPVC casing/screen    | NA             | NA             |
| GW-21D                  | 03/05/81                     | 84.1                           | 86.08                                | 74.6-69.6              | 9.5-14.5         | 80.1-69.1              | 4.0-15.0       | 2"OPVC casing/screen     | 15.0           | 69.1           |
| GW-22S                  | 03/05/81                     | 85.6                           | 87.32                                | 75.6-70.6              | 10.0-15.0        | 77.6-70.6              | 8.0-15.0       | 2"ØPVC casing/screen     | NA             | NA             |
| GW-22D                  | 03/04/81                     | 85.6                           | 87.06                                | 55.6-50.6              | 30.0-35.0        | 70.6-49.6              | 15.0-36.0      | 2°ØPVC casing/screen     | 36.0           | 49.6           |
| GW-22D                  | 03/04/01                     | 88.5                           | 90.93                                | 33.0-30.0              | 30.0-33.0        | 70.0-47.0              | 15.0 00.0      | E DI TO CASHIN/SCITCH    | 15.0           | 73.5           |
| GW-24                   |                              | 002                            | 83.57                                | s                      | s                | S                      | s              |                          | NA             | NA             |
| GW-25                   |                              |                                | 85.99                                | s                      | S                | S                      | Š              |                          | NA             | NA             |
| GW-26                   |                              |                                | 84.96                                | S                      | S                | S                      | Š              |                          | NA             | NA             |
| GW-27S                  | 06/19/86                     | 88.1                           | 89,40                                | 78.1-68.1              | 10.0-20.0        | ?-68.1                 | ?-20.0         | 1.5"Ø PVC casing/screen  | NA             | NΑ             |
| GW-27D                  | 06/20/86                     | 88.4                           | 89.40                                | 67. <b>5</b> -57.5     | 20.9-30.9        | 7-57.5                 | ?-30.9         | 15"0 PVC casing/screen   | NA<br>NA       | NA             |
|                         | · ·                          | 83.6                           | 85.57                                | 81.6-71.6              | 2.0-12.0         | ?-71.6                 | ?-12.0         | 1.5"Ø PVC casing/screen  | NA.            | NΑ             |
| GW-285                  | 06/27/86                     | 83.5                           | · ·                                  | 79.2-69.2              | 4.3-14.3         | ?-69.2                 | ?14.3          | 1.5 © PVC casing/screen  | 14.3           | 69.2           |
| GW-28D                  | 06/27/86                     |                                | 84.81                                |                        |                  | 1-69.4<br>2-69.9       | ?-14.0         | 1.5 © PVC casing/screen  |                | NA             |
| GW-29S                  | 07/03/86                     | 83.9                           | 84.27                                | 79.9-69.9              | 4.0-14.0         |                        | ?-29.0         |                          | NA<br>NA       | NA<br>NA       |
| GW-29D                  | 07/10/86                     | 83.8                           | 84.58                                | 64.8-54.8              | 19.0-29.0        | ?-54.8                 |                | 1.5" PVC casing/screen   |                |                |
| GW-30S*                 | 07/02/86                     | 90,9                           | 91.0                                 | 81.9-71.9              | 9.0-19.0         | ?-71.9                 | ?-19,0         | 15"Ø PVC casing/screen   | NA<br>30 F     | NA<br>49.2     |
| GW-30DR                 | 11/18/87                     | 87.7                           | 89.32                                | 56.2-46.2              | 31.5-41.5        | ?-46.2                 | ?-41.5         | 2" OPVC casing /screen   | 39.5           | 48.2           |
| GW-30D*                 | 06/30/86                     | 90.7                           | 85.57                                | 58.0-48.0              | 32.7-42.7        | ?-48.0                 | ?-42.7         | 1.5"Ø PVC casing/screen  | 42.7           | 48.0           |

## MONITORING WELL COMPLETION DETAILS SUMMARY WILMINGTON FACILITY

|            |                   |                  |                     |                   | reened) Interval |                        | ck Interval    |                       | Top of Be       |                 |
|------------|-------------------|------------------|---------------------|-------------------|------------------|------------------------|----------------|-----------------------|-----------------|-----------------|
| Monitoring | Date Completed    | Ground Elevation | Top of Casing       | Elevation         |                  | Elevation              |                |                       |                 |                 |
| Well I.D.  | (mm/dd/yy)        | (ft. AMSL)       | Elevation (ft AMSL) | (ft AMSL)         | Depth (ft bgs)   | (ft AMSL)              | Depth (ft bgs) | Well Materials        | Depth (ft bgs)  | Elev (ft AMSL)  |
| GW-315     | 04/12/88          |                  | 91.41               |                   | 6.0-16.0         |                        | ?-16.0         | 2°Ø SS casing/screen  | NA              | NA ·            |
| GW-31D     | 04/12/88          | 67.2             | 91.68               | 55.2 - 4S.2       | 12.0-22.0        | ? - 45,2               | ?-22.0         | 2º10/5S casing/screen | 22.0            | 67.2            |
| GW-32S     | 04/14/88          |                  | 87.74               |                   | 5.0-15.0         |                        | ?-15.0         | 2°Ø 5S casing/screen  | NA              | NA              |
| GW-32D     | 04/14/88          | 86.7             | 89.20               | 65.7 - 55.7       | 21.0-31.0        | ? - 55.7               | ?-31.0         | 2"Ø SS casing/screen  | 26.0            | 60,7            |
| GW-335     | 11/13/89          | 87.4             | 89.88               | 77.4-67.4         | 10.0-20.00       | 78.4-67.4              | 9.0-20.0       | 2"ØPVC casing/screen  | NA              | NΑ              |
| GW-33D     | 11/13/89          | 88.1             | 89.64               | 71.1-61.1         | 16.0-26.0        | 73.1-61.1              | 14.0-26.0      | 2"ØPVC casing/screen  | 19.4            | 68,7            |
| GW-34S     | 11/17/89          | 87.7             | 90.21               | 77.7-67.7         | 10.0-20.0        | 78.7 <del>-67</del> .7 | 9.0-20.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-34D     | 11/20/89          | 88.0             | 90.27               | 65.3-55.3         | 23.0-33.0        | 68.3-55.3              | 20.0-33.0      | 2"ØPVC casing/screen  | Boulders (24.5) | Boulders (63.5) |
| GW-35S     | 11/28/89          | 87.1             | 89.57               | 77.1-67.1         | 10.0-20.0        | 79.1-67.1              | 8.0-20.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-35D     | 11/25/89          | 88.1             | 89.76               | S7,3-47.3         | 30.0-40.0        | 59.3-47.3              | 28.0-40.0      | 2"ØPVC casing/screen  | 35.0            | 53.1            |
| GW-36      | 11/16/89          | 84.3             | 85.77               | 57.3-47.3         | 27.0-37.0        | 61.3-47.3              | 23.0-37.0      | 2"ØPVC casing/screen  | 36.5            | 47.8            |
| GW-37      | 11/?/89           | 81.8             | 83,51               | 62.5-52.5         | 19.5-29.5        | 68.0-52.5              | 14.0-29.5      | 2"ØPVC casing/screen  | 27.0            | 55.0            |
| GW-38      | 11/13/89          | 85.9             | 86. <del>9</del> 5  | 65.0-55.0         | 20.5-30.5        | 71.5-55.0              | 14.0-30.5      | 2"ØPVC casing/screen  | 28.0            | 57.5            |
| GW-39      | 11/28/89          | 81.7             | 83.55               | 78.6-68.6         | 3.0-13.0         | 80.6-68.6              | 1.0-13.0       | 2"ØPVC casing/screen  | 8.0             | 73.6            |
| GW-40D     | 07/26/91          | 86.4             | 88.00               | 51.4-41.4         | 35.0-45.0        | 53.4-41.4              | 33.0-45.0      | 2"ØPVC casing /screen | 39.0            | 47.4            |
| GW-405     | 07/26/91          | 86.4             | 88.46               | 76.4-66.4         | 10.0-20.0        | 78.4-66.4              | 8.0-20.0       | 2"ØPVC casing/screen  | NΑ              | NΑ              |
| GW-42D     | 07/21/91          | 84.4             | 84.41               | 50.4-40.4         | 34.0-44.0        | 54.4-40.4              | 30.0-44.0      | 2°0PVC casing/screen  | 39.0            | 45.4            |
| GW-42S     | 07/21/91          | 84.5             | 84.52               | 76.0-66.0         | 8.5-18.5         | 78.5-66.0              | 6.0-18.5       | 2"ØPVC casing/screen  | NA              | NΑ              |
| GW-43D     | 07/18/91          | 85.6             | 87,97               | 60.6-50.6         | 25.0-35.0        | 65.6-50.6              | 20.0-35.0      | 2"ØPVC casing/screen  | 29.0            | 56.5            |
| GW-43S     | 07/18/91          | 85.6             | 87.36               | 77.6-67.6         | 8.0-18.0         | 79.6-67.6              | 6.0-18.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-44S     | 04/24/92          | 84.0             | 85.70               | 74.0-64.0         | 10.0-20.0        | 76.0-64.0              | 8.0-20.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-44Đ     | 04/24/92          | 83.5             | 93,97               | 28.5-18.5         | 55.0-65.0        | 30.5-16.5              | 53.0-67.0      | 2"ØPVC casing/screen  | 61.0            | 22.5            |
| GW-45S     | 12/11/92          | 89.9             | 89.43               | 77.9-67.9         | 12.0-22.0        | 81.9-67.9              | 8.0-22.0       | 2"ØPVC casing/screen  | NA              | NΑ              |
| GW-45D     | 12/11/92          | 89.8             | 89.36               | 37.3-27.3         | 52.5-62.5        | 41.8-25.3              | 48.0-64.5      | 2"ØPVC casing/screen  | 60.0            | 29.8            |
| GW-46D     | 01/31/92          | 84.2             | 85.90               | 76.2-66.2         | 8.0-18.0         | 78.2-66.2              | 6.0-18.0       | 2"ØPVC casing/screen  | 14.0            | 70.2            |
| GW-47      | 08/02/91          | 91.6             | 93.18               | 87.6-77.6         | 4.0-14.0         | 88.6-77.6              | 3.0-14.0       | 2"ØPVC casing/screen  | 3.0             | 88.6            |
| GW-48D     | 07/16/91          | 89.0             | 90.86               | 48.0-38.0         | 41.0-51.0        | 60.0-48.0              | 29.0-41.0      | 2"ØPVC casing/screen  | 36.0            | 53.0            |
| GW-485     | 07/16/91          | 88.9             | 91.14               | 76.9-66.9         | 12.0-22.0        | 78.9-66.9              | 10.0-22.0      | 2"OPVC casing/screen  | NA              | NA              |
| GW-49D     | 12/14/92          | 79.2             | 81.37               | 71.2-61.2         | 8.0-18.0         | 73.2-61.2              | 6.0-18.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-50D     | 06/27/91          | 77.4             | 80.11               | 47.4-37.4         | 30.0-40.0        | 49.4-37.4              | 28.0-40.0      | 2"ØPVC casing/screen  | 35.0            | 42.4            |
| GW-50S     | 06/27/91          | 77.0             | 79. <b>7</b> 1      | 72.0-62.0         | 5.0-15.0         | 73.0-62.0              | 4.0-15.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-51D     | 06/19/91          | 82.8             | <b>84</b> .52       | 71.8-61.8         | 11.0-21.0        | 75.0-63.8              | 7.8-19.0       | 2"ØPVC casing/screen  | 14.0            | 68.8            |
| GW-51S     | 06/19/91          | 82.9             | 84.59               | 79.9-74.9         | 3.0-8.0          | 80.4-74.9              | 2.5-8.0        | 2"ØPVC casing/screen  | NΑ              | NA              |
| GW-52D     | 06/18/91          | 85.8             | 88.00               | 73.8-63.8         | 12.0-22.0        | 76.8-63.8              | 9.0-22.0       | 2"ØPVC casing/screen  | 15.0            | 70.8            |
| GW-52S     | 06/13/91          | 85.8             | 87.99               | 80.6-75.6         | 5.0-10.0         | 82.6-75.1              | 3.0-10.5       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-53D     | 06/17/91          | 89.3             | 91.88               | 77.8-67.8         | 11.5-21.5        | 79.8-67.3              | 9.5-22.0       | 2"ØPVC casing/screen  | 15.0            | 74.3            |
| GW-53S     | 06/13/91          | 89.0             | 90.69               | 83.5-78.5         | 5.5-10.5         | 86.0-78.5              | 3.0-10.5       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-54D     | 06/14/91          | 86.6             | 89.15               | 76.1-66.1         | 10.5-20.5        | 77.6-66.1              | 9.0-20.5       | 2'ØPVC casing/screen  | 15.3            | 71.3            |
| GW-54S     | 06/13/91          | 86.4             | 88.69               | 81.4-76.4         | 5.0-10.0         | 82.4-76.2              | 4.0-10.2       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-55D     | 07/02/91          | 79.7             | 81.73               | <b>69.7-59.7</b>  | 10.0-20.0        | 69.7-59.7              | 10.0-20.0      | 2"ØPVC casing/screen  | 14.0            | 65.7            |
| GW-55S     | 07/02/91          | 79.8             | 81.44               | 74.8-69.8         | 5.0-10.0         | 75.8-69.8              | 4.0-10.0       | 2"ØPVC casing/screen  | NA              | NA              |
| GW-56D     | 0 <b>7/09/</b> 91 | 80.5             | 82.76               | 65,5-55.5         | 15.0-25.0        | 67.5-55.5              | 13.0-25.0      | 2"ØPVC casing/screen  | 19.5            | 61              |
| GW-56S     | 07/09/91          | 80.6             | 83.01               | 75.6-65.6         | 5.0-15.0         | 77.6-65.6              | 3.0-15.0       | 2"ØPVC casing/screen  | NA              | NΛ              |
| GW-57D     | 01/29/91          | 95.3             | 94.99               | 74.3-64.3         | 21.0-31.0        | 77.3-64.3              | 18.0-31.0      | 2"ØPVC casing/screen  | 26.0            | 69.3            |
| GW-58D     | 08/03/92          | 96.1             | 98.19               | <b>26</b> .1-16.1 | 70.0-80.0        | 29.1-16.1              | 67.0-80.0      | 2"ØPVC casing/screen  | 74.0            | 22.1            |
| GW-58S     | 08/03/92          | 96.0             | 98.21               | 78.0-68.0         | 18.0-28.0        | 80.0-68.0              | 16.0-28.0      | 2"ØPVC casing/screen  | NA              | NA              |
| GW-588     | 08/03/92          | <b>96.</b> U     | 98.21               | 78.0-68.0         | 18.0-28.0        | 80.0-68.0              | 16.0-28.0      | Z10PVC casing/screen  | NA              | NA              |

# MONITORING WELL COMPLETION DETAILS SUMMARY WILMINGTON FACILITY

|                  |                  |                  |                     | Monitored (Sc      | reened) Interval | _Sand Pa          | ck Interval     |                             | Top of Bedrock                          |                |
|------------------|------------------|------------------|---------------------|--------------------|------------------|-------------------|-----------------|-----------------------------|---|----------------|
| Monitoring       | Date Completed   | Ground Elevation | Top of Casing       | Elevation          |                  | Elevation         |                 |                             | *************************************** | ,              |
| Well I.D.        | (mm/dd/yy)       | (ft. AMSL)       | Elevation (ft AMSL) | (ft AMSL)          | Depth (ft bgs)   | (ft AMSL)         | Depth (ft bgs)  | Well Materials              | Depth (ft bgs)                          | Elev (ft AMSL) |
| GW-59S           | 02/07/92         | 85.3             | 85.08               | 75.3-65.3          | 10.0-20.0        | 77.3-65.3         | 8.0-20.0        | 2"ØPVC casing/screen        | NA                                      | NΛ             |
| GW-59D           | 02/07/92         | 85.2             | 85.06               | 36,2-21.2          | 49.0-64.0        | 38.2-20.2         | 47.0-65.0       | 2"ØPVC casing/screen        | 60.0                                    | 25.2           |
| GW-60S           | 04/29/92         | 88.9             | 90.48               | 81.9-71.9          | 7.0-17.0         | 83.9-70.9         | 5.0-18.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-60D           | 04/29/92         | 88.6             | 90.73               | 67.6-57.6          | 21.0-31.0        | 70.6-57.6         | 18.0-31.0       | 2°ØPVC casing/screen        | 26.0                                    | 62.6           |
| GW-61BR          | 12/17/92         | 81.6             | 83.67               | 9.610.4            | 72.0-92.0        | NA                | NΛ              | 4"ØPVC casing               | 72.0                                    | 9.6            |
| CW-61S           | 04/30/92         | 81.7             | 83.51               | 71.7-61.7          | 10.0-20.0        | 73.7-61.7         | 8.0-20.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-61D           | 04/30/92         | 81.5             | 83.66               | 40.5-30.5          | 41.0-51.0        | 43.5-29.5         | 38.0-52.0       | 2"ØPVC casing/screen        | 48.0                                    | 33.5           |
| GW-62BRD         | 01/06/93         | 82.0             | 83.66               | -23.063.0          | 105.0-145.0      | NA .              | NΑ              | 4"ØPVC casing               | 80.0                                    | 2.0            |
| GW-62BR          | 07/22/92         | 81.6             | 83.67               | -1.623.4           | 80.0-105.0       | NA                | NA              | 4"ØPVC casing               | 80.0                                    | 1.6            |
| GW-62S           | 05/05/92         | 82.3             | 84.61               | 77. <b>3</b> -67.3 | 5.0-15.0         | 79.3-67. <b>3</b> | 3.0-15.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-62D           | 05/04/92         | 82.4             | 83.84               | 21.4-11.4          | 61.0-71.0        | 24.4-7.4          | 58.0-75.0       | 2"ØPVC casing/screen        | 70.0                                    | 12.4           |
| GW-62M           | 05/05/92         | 82.4             | 84.38               | 52.4-42.4          | 30.0-40.0        | 54.4-42.4         | 28.0-40.0       | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-63S           | 08/05/92         | 81.1             | 82.82               | 73.1-63.1          | 8.0-18.0         | 75.1-63.1         | 6.0-18.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-63D           | 08/05/92         | 81.1             | 83.32               | 57.1-47.1          | 24.0-34.0        | 62.1-47.1         | 19.0-34.0       | 2"ØPVC casing/screen        | 29.0                                    | 52.1           |
| GW-64S           | 07/31/92         | 84.6             | 86.70               | 74.1-64.1          | 10.5-20.5        | 76.1-64.1         | 8.5-20.5        | 2"OPVC casing/screen        | NA                                      | NA             |
| GW-64D           | 07/31/92         | 84.1             | 85.96               | 28.1-18.1          | 56.0-66.0        | 37.1-16.1         | 47.0-68.0       | 2"ØPVC casing/screen        | 63.5                                    | 20.6           |
| GW-65S           | 08/07/92         | 82.4             | 84.14               | 74.4-64.4          | 8.0-18.0         | 76.4-64.4         | 6.0-18.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-65D           | 08/05/92         | 82.4             | 84.19               | -3.118.1           | 85.5-100.5       | -1.121.1          | 83.5-100.5      | 2"ØPVC casing/screen        | 93.3                                    | -10.9          |
| GW-66S           | 08/03/92         | 88.4             | 90.15               | 79.4-69.4          | 9.0-19.0         | 81.4-69.4         | 7.0-19.0        | 2"@PVC casing/screen        | NA                                      | NA.            |
| GW-66D           | 07/22/92         | 88.3             | 90.37               | 55.3-44.3          | 33.0-43.0        | 57.3-40.8         | 31.0-47.5       | 2"ØPVC casing/screen        | 40.0                                    | 48.3           |
| GW-67S           | 11/02/92         | 98.4             | 100.61              | 80.9-70.9          | 17.5-27.5        | 83.4-70.4         | 15.0-28.0       | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-67D           | 11/02/92         | 98.2             | 100.39              | 25,7-10.7          | 72.5-87.5        | 30.2-10.2         | 68.0-88.0       | 2"ØPVC casing/screen        | 81.0                                    | 17.2           |
| GW-68BR          | 12/10/92         | 90.2             | 89.83               | 59.2-14.2          | 31.0-76.0        | NA                | NA              | 4"ØPVC casing               | 31.0                                    | 59.2           |
| GW-68D           | 07/23/92         | 90.3             | 90.16               | 83,3-73,3          | 7.0-17.0         | 85.3-72.3         | 5.0-18.0        | 2"ØPVC casing/screen        | 14.0                                    | 76.3           |
| GW-69S           | 07/27/92         | 90.9             | 92.28               | <b>7</b> 7.9-67.9  | 13.0-23.0        | 82.4-67.9         | 8.5-23.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-69D           | 07/27/92         | 91.1             | 93.05               | 55,1-45.1          | 36.0-46.0        | 57.1-45.1         | 34.0-46.0       | 2"ØPVC casing/screen        | 45.0                                    | 46.1           |
| GW-70S           | 07/26/92         | 92.2             | 91.99               | 78.2-68.2          | 14.0-24.0        | 80.2-68.2         | 12.0-24.0       | 2"OPVC casing/screen        | NA                                      | NA             |
| GW-70D           | 07/28/92         | 92.3             | 92.10               | 40.3-30.3          | 52.0-62.0        | 42.3-30.3         | 50.0-62.0       | 2"ØPVC casing/screen        | 57.0                                    | 35.3           |
| GW-71D           | 11/19/92         | 94.4             | 96.65               | 54,4-44.4          | 40.0-50,0        | 57.4-44.1         | 37.0-50.3       | 2"ØPVC casing/screen        | 45.0                                    | 49.4           |
| GW-71S           | 11/17/92         | 93.9             | 95,60               | 80,9-70.9          | 13.0-23.0        | 87.9-70.9         | 6.0-23.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-72D           | 11/17/92         | 86.0             | 88.19               | 74,0-64.0          | 12.0-22.0        | 76.0-61.0         | 10.0-25.0       | 2"ØPVC casing/screen        | 17.0                                    | 69             |
| GW-73D           | 04/19/93         | 83.8             | 83.49               | 29.3-19.3          | 54.5-64.5        | 31.3-19.3         | 52.5-64.5       | 2°ØPVC casing/screen        | 58.0                                    | 25.8           |
| GW-73S           | 04/19/93         | 83.4             | 83.39               | 68.4-58.4          | 15.0-25.0        | 70.4-58.4         | 13.0-25.0       | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-74D           | 03/31/93         | 77.7             | 77.22               | 57.2-47.2          | 20.5-30.5        | 59.7-47.2         | 18.0-30.5       | 2"ØPVC casing/screen        | 25.0                                    | 52.7           |
| GW-74S           | 03/31/93         | 77.7             | 77.43               | 67. <b>7</b> -57.7 | 10.0-20.0        | 69.7-57.7         | 8.0-20.0        | 2"ØPVC casing/screen        | NA                                      | NA             |
| GW-75D           | 05/06/93         | 81.4             | 83.49               | 45.4-35.4          | 36.0-46.0        | 47.4-35.4         | 34.0-46.0       | 2"ØPVC casing/screen        | 41.0                                    | 40.4           |
| GW-75S           | 05/06/93         | 81.1             | 83.28               | 71.1-61.1          | 10.0-20.0        | 73.1-61.1         | 8.0-20.0        | 2"OPVC casing/screen        | NA                                      | NA             |
| G11-755          | W/ 00/ 30        | 01.1             | . 00.20             | 71.1-01.1          | 10.0-20.0        | 75.1-01.1         | 0.0~20.0        | 2 to 1 v C Cashing / screen | NA                                      | 1474           |
| Sulfate Landfill | Monitoring Wells |                  |                     |                    |                  |                   |                 |                             |   |                |
| SLIS             | 11/11/87         |                  | 86.47               |                    | 5.0-15,0         |                   | ?-15.0          | 2"Ø PVC casing/screen       | NA                                      | NA             |
| SL1D             | 11/12/87         |                  | 86.44               |                    | 4.5-14.5         |                   | 7-14.5          | 2"Ø PVC casing/screen       | 12.5                                    | 71.6           |
| SL2              | 11/13/87         |                  | 85.80               |                    | 5.0-15.0         |                   | 7-15.0          | 2"Ø PVC casing/screen       | 13.0                                    | 70.5           |
| SL3              | 11/20/87         |                  | 92.64               |                    | 11.0-21.0        |                   | ?-21.0          | 2°Ø PVC casing/screen       | 19.0                                    | 71.2           |
| SL4              | 11/16/87         |                  | 103.19              |                    | 5.7-10.7         |                   | ?-10.7          | 2"Ø PVC casing/screen       | 8.0                                     | 92.7           |
| SL5              | 11/17/87         |                  | 94.41               |                    | 5.0-15.0         |                   | ?-15.0          | 2º0 PVC casing/screen       | 13.0                                    | 79.8           |
| SL6              | 11/18/87         |                  | 92.71               |                    | 11.0-21.0        |                   | ?-21.0          | 2"Ø PVC casing/screen       | 19.0                                    | <b>7</b> 1.1   |
| SL7              | 11/19/87         |                  | 95.25               |                    | 5.0-10.0         |                   | ?-1 <b>0</b> .0 | 2º0 PVC casing/screen       | 7.0                                     | 86.3           |
| SL8              | 11/19/87         |                  | 92.42               |                    | 1.0-6.0          |                   | 7-6.0           | 2ºØ PVC casing/screen       | 3.0                                     | 87.9           |
|                  | -                |                  |                     |                    |                  |                   |                 | 9                           | -                                       | •              |

TABLE 4.4

### MONITORING WELL COMPLETION DETAILS SUMMARY WILMINGTON FACILITY

|               |                |                  |                        | Monitored (Screened) Interval |                | Sand Pack Interval |                |                        | Top of Bedrock |                |
|---------------|----------------|------------------|------------------------|-------------------------------|----------------|--------------------|----------------|------------------------|----------------|----------------|
| Monitoring    | Date Completed | Ground Elevation | Top of Casing          | Elevation                     |                | Elevation          |                |                        |                |                |
| Well I.D.     | (mm/dd/yy)     | (ft. AMSL)       | Elevation (ft AMSL)    | (ft AMSL)                     | Depth (ft bgs) | (ft AMSL)          | Depth (ft bgs) | Well Materials         | Depth (ft bgs) | Elev (ft AMSL) |
| Other Plant W | Vells          |                  | ÷                      |                               |                | •                  |                | •                      |                |                |
| OW-1          | 02/10/82       |                  |                        |                               | 5.0-15.0       |                    |                | 4"PVC Casing/Screen    | 15.0           | -              |
| OW-2          | 02/10/82       |                  |                        |                               | 5.0-15.0       |                    |                | 4°PVC Casing/Screen    | 13.0           |                |
| OW-3          | 02/11/82       |                  |                        |                               | 5.0-15.0       |                    |                | 4"PVC Casing/Screen    | -              |                |
| OW-4          | 02/11/82       |                  |                        |                               | 7.0-17.0       |                    |                | 4"PVC Casing/Screen    | 15.0           |                |
| OB-1          |                |                  | 85.92                  |                               | 4.0-19.0       |                    |                |                        | 19.0           |                |
| OB-2          |                |                  | 88.00                  |                               | 7.5-27.5       |                    |                |                        | 27.5           |                |
| OB-3          |                |                  | 88.16                  |                               | 3.0-28.0       |                    |                |                        | 28.0           |                |
| OB-4          |                |                  | 89.41                  |                               | 6.0-21.0       |                    |                |                        | 21.0           |                |
| PW-I          |                | 86.8             | 87.45                  | 78.8-28.8                     | 8.0-28.0       |                    |                | •                      | 27.0           | 59.8           |
| PW-2          | 11/30/87       | 87.5             | 89.14                  | 79.5-49.5                     | 8.0-38.0       | 82.5-49.5          | 5.0-38.0       | 6" Ø PVC Casing/Screen | 38.0           | 49.5           |
| GT4S          |                |                  | 86,39                  |                               | 4.0-9.0        |                    |                |                        |                |                |
| GT4D          |                | 86.3             | 88,51                  | 77.3-62.3                     | 9.0-24.0       |                    |                |                        | 28.0           | 58.3           |
| G75           |                | 84.1             | 88.03                  | 67.6-52.6                     | 16.5-31.5      |                    |                |                        | 34.0           | 50.1           |
| GT6S          |                |                  | 87.40                  |                               | 3.5-8.5        |                    |                |                        |                |                |
| GT6D          |                | 86.5             | 87,25                  | 68.5-53.5                     | 18.0-33.0      |                    |                |                        | 36.5           | 50.0           |
| G17           |                |                  | 90.51                  |                               | 0.3-25.3       |                    |                |                        |                |                |
| GT8           |                | 91.6             |                        |                               |                |                    |                |                        | 31.0           | 60.6           |
| GT9S          |                |                  | 86.97                  |                               | 4.0-9.0        |                    |                |                        |                |                |
| GT9D          |                |                  | 87.62                  |                               | 18.0-33.0      |                    |                |                        |                |                |
| PID           |                |                  | <b>8</b> 9. <b>7</b> 7 | ?-71.2                        |                |                    |                |                        |                |                |
| P3            |                |                  | 88.94                  | ?-81.3                        |                |                    |                |                        |                |                |
| P4            |                |                  | 88.73                  | 7-76.1                        |                |                    |                |                        |                |                |
| P5            |                |                  | 88.03                  | ?-73.9                        |                |                    |                |                        |                |                |
| IWI           |                |                  | 89.32                  |                               |                |                    |                | ÷                      |                |                |
| IW2           |                | •                | 89.60                  |                               |                |                    |                |                        |                |                |
| IW3           |                |                  | 89.35                  |                               |                |                    |                |                        |                |                |
| IW4           |                |                  | 89.66                  |                               |                |                    |                | •                      |                |                |
| IW6           |                |                  | <b>8</b> 9.15          |                               |                |                    |                |                        |                |                |
| IW7           |                |                  | 90.09                  |                               |                |                    |                |                        |                |                |
| IW8           |                |                  | 89. <b>8</b> 9         |                               |                |                    |                |                        |                |                |
| IW9           |                |                  | 89.74                  |                               |                |                    |                |                        |                |                |
| TW10          |                |                  | 90.34                  |                               |                |                    |                |                        |                |                |
| IW11          |                |                  | 89.92                  |                               |                |                    |                |                        |                |                |
| IW12          |                |                  | 90.31                  |                               |                |                    |                |                        |                |                |
| IW13          |                |                  | 89.90                  |                               |                |                    |                |                        |                |                |
| JOB           |                |                  | 88.20                  |                               |                |                    |                |                        |                |                |
| JOD           |                | 87.0             | 89.99                  |                               |                | •                  |                |                        |                |                |
|               |                |                  |                        |                               |                |                    |                |                        |                |                |

### MONITORING WELL COMPLETION DETAILS SUMMARY WILMINGTON FACILITY

|            |                |                  |                     | Monitored (Sc | reened) Interval | Sand Pa   | ck Interval    |                | Top of         | Bedrock        |
|------------|----------------|------------------|---------------------|---------------|------------------|-----------|----------------|----------------|----------------|----------------|
| Monitoring | Date Completed | Ground Elevation | Top of Casing       | Elevation     |                  | Elevation |                |                |                |                |
| Well I.D.  | (mm/dd/yy)     | (ft. AMSL)       | Elevation (ft AMSL) | (ft AMSL)     | Depth (ft bgs)   | (ft AMSL) | Depth (ft bgs) | Well Materials | Depth (ft bgs) | Elev (ft AMSL) |
| JOE        |                | 87.5             | 89.78               |               |                  |           |                |                |                |                |
| JOF        |                | 87.0             | 89.93               |               |                  |           |                |                |                |                |
| JOG        |                |                  | 90.10               |               |                  |           |                |                |                |                |
| JOH        |                |                  | 90.51               |               |                  |           |                |                |                |                |
| JOI        |                |                  | 91.73               |               |                  |           |                |                |                |                |
| B2         | 10/16/87       |                  | 88.44               | ?-74.4        |                  |           |                |                | 23.0           |                |
| B3         | 10/18/87       |                  | 88.91               | ?-74.6        |                  |           |                |                | 24.0           |                |
| B5         | 10/19/87       |                  | 90.39               | ?-78.4        |                  |           |                |                | 24.0           |                |
| B7A        | 10/21/87       |                  | 89.03               | ?-78.5        |                  |           |                |                | 23.0           |                |
| B15*       | +              |                  | 90.07               |               |                  |           |                |                |                |                |
| B17        |                |                  | 90.67               | ?-77.5        |                  |           |                |                |                |                |
| 12-IN      |                |                  | 89.78               |               |                  |           |                |                |                |                |

### Notes:

ft bgs - feet below ground surface

<sup>\* -</sup> destroyed

NA - Not applicable/not determined S - Shallow well, depth and screen not recorded (t AMSL - feet above Mean Sea Level

**TABLE 4.5** 

# HYDRAULIC CONDUCTIVITY DATA RESULTS WILMINGTON FACILITY

| Well No.          | Hydraulic Conductivity (cm/sec)(1) |                      |                           |  |  |  |  |
|-------------------|------------------------------------|----------------------|---------------------------|--|--|--|--|
| Slug Test Results | Falling<br>Head Test               | Rising<br>Head Test  | Average                   |  |  |  |  |
| 40 <b>D</b>       | $>1 \times 10^{-2}$                | ****                 | >1 × 10 <sup>-2</sup> (2) |  |  |  |  |
| 42D               | $>1 \times 10^{-2}$                | ******               | >1 × 10 <sup>-2</sup> (2) |  |  |  |  |
| 43D               | $1 \times 10^{-2}$                 | $9.0 \times 10^{-3}$ | $9.5 \times 10^{-3}$      |  |  |  |  |
| 50 <b>D</b>       | $>1 \times 10^{-2}$                | *****                | $>1 \times 10^{-2}$ (2)   |  |  |  |  |
| 51 <b>D</b>       |                                    | $9.7 \times 10^{-4}$ | $9.7 \times 10^{-4}$      |  |  |  |  |
| 54 <b>D</b>       | $5.3 \times 10^{-3}$               | $3.4 \times 10^{-3}$ | $4.4 \times 10^{-3}$      |  |  |  |  |
| 55 <b>D</b>       | $4.3 \times 10^{-3}$               | $1.1 \times 10^{-2}$ | $7.7 \times 10^{-3}$      |  |  |  |  |
| 56D               | $7.7 \times 10^{-2}$               | $2.1 \times 10^{-2}$ | $4.9 \times 10^{-2}$      |  |  |  |  |
|                   |                                    | Geometric Mean       | $7.9 \times 10^{-3}$      |  |  |  |  |

| Pumping Test F | <u>Results</u>        |                          |                          |
|----------------|-----------------------|--------------------------|--------------------------|
| _              | Drawdou               | n Test                   | Recovery Test            |
|                | Theis<br>Solution     | Cooper-Jacob<br>Solution | Cooper-Jacob<br>Solution |
| GW-62BR        | $1.20 \times 10^{-5}$ | 2.26 x 10 <sup>-5</sup>  | $2.13 \times 10^{-5}$    |
| GW-62BRD       |                       |                          | $1.27 \times 10^{-5}$    |

### Notes:

- (1) See Appendix F for Hydraulic Conductivity Test Results/Calculations.
- (2) Hydraulic conductivities assumed equal to 1 x 10<sup>-2</sup> cm/sec for calculating geometric mean.

TABLE 4.6

## SUMMARY OF GROUNDWATER ELEVATIONS WILMINGTON FACILITY

Water Level (ft AMSL)

|                         |                                      |               |               | Wat           | er Level (ft A | MSL)          |          |               |
|-------------------------|--------------------------------------|---------------|---------------|---------------|----------------|---------------|----------|---------------|
| Monitoring<br>Well I.D. | Top of Casing<br>Elevation (ft AMSL) | 09/30/91      | 02/11/92      | 07/22/92      | 08/14/92       | 09/03/92      | 01/07/93 | 04/21/93      |
| GW Monitorin            | g Wells                              |               |               |               |                |               |          |               |
| GW-1                    | 88.89                                |               | 79.99         |               | 79.94          | 79.90         | 80.61    | 80.71         |
| GW-3S                   | 86.69                                | 79.74         | <i>79.79</i>  | 78.14         | 78.23          | 78.19         | 81.06    | 81.13         |
| GW-3D                   | 85.23                                | 79.93         | 79.33         | 78.08         | 78.41          | 78.37         | 80.82    | 80.81         |
| GW-4                    | 82.12                                | 76.31         | 76.42         | <i>7</i> 5.52 | <b>78.78</b>   | 75.66         | 76.76    | 76.84         |
| GW-4D                   | 79.23                                | 76.66         | 76.13         | 75.41         | <del></del>    | 75.62         | 77.07    | 77.07         |
| GW-5                    | 79.46                                |               | 76.61         | <i>7</i> 5.26 | •••            | 75.49         | 76.89    | 76.84         |
| GW-6S                   | 88.72                                | 82.22         | 81.32         | 80.77         | 79.87          | 80.98         | 82.77    | 83.17         |
| GW-6D                   | 89.43                                | 81.66         | 80.83         | 80,18         | 80.27          | 80.47         | 82.11    | 82.32         |
| GW-8                    | 83.19                                | <b>78.67</b>  |               | 76.76         | <i>7</i> 7.95  | 76.86         | 79.10    | 79.03         |
| GW-105                  | 89.61                                | 80.96         | 81.11         | 80.16         | 80.32          | 81.74         | 81.81    | 81.39         |
| GW-10D                  | 84.19                                | 81.06         | 80.79         | 80.29         | 80.32          | 80.35         | 81.32    | 81.47         |
| GW-11                   | 87.22                                | 80.71         | 80.22         | 79.67         | 80.03          | 80.00         | 80.99    | 81.05         |
| GW-12                   | 84.62                                | 81.02         | 81.02         | 79.80         | 80.27          | 79.80         | 81.65    | 81.61         |
| GW-13                   | 90.62                                | 78.92         | -             |               | -              | DRY           | DRY      | 79.10         |
| GW-15                   | 90.07                                |               | 79.97         | 79.67         | 79.83          | 79.90         | 81.35    | 81.96         |
| GW-17S                  | 82.10                                | 78.81         | 78.30         | 76.75         | DRY            | <i>7</i> 7.05 | 79.24    | 79.14         |
| GW-17D                  | 81.46                                | <b>78.7</b> 5 | 78.26         | ***           | <i>7</i> 7.52  | <i>7</i> 7.19 | 79.14    | 79.14         |
| GW-18S                  | 89.64                                | DRY           | DRY           | DRY           | DRY            | DRY           | 78.94    | 79.27         |
| GW 18D                  | 88.96                                | 76.21         | <i>7</i> 5.21 | 75.21         | 75.14          | 75.02         | 78.11    | 79.02         |
| GW-19S                  | 89.88                                | 81.53         | -             | ***           | 80.14          | 80.23         | 82.15    | 82.16         |
| GW-19D                  | 89.78                                | 81.28         |               | <del></del>   | 80,20          | 80.27         | 81.68    | 81.74         |
| GW-20                   | 85.60                                | 78.00         | 76.79         | 76.79         | 76.25          | 76.35         | 80.21    | 80.26         |
| GW-215                  | 90.90                                | 83.52         | 82.20         | 82,20         | •              | 82.47         | 83.80    | 83.85         |
| GW-21D                  | 86.08                                | 83.19         | 81.53         | 81.53         | 82.08          | 81.68         | 83.63    | 83.78         |
| GW-22S                  | 87.32                                | 82.90         | 80.92         | 80.92         | 80.92          | 81.22         | 83.05    | 83.10         |
| GW-22D                  | 87.06                                | 80.87         | 79.91         | <b>79</b> .91 |                | 79.78         | 81.16    | 81.50         |
| GW-24                   | 83.57                                | 80.62         | 80.37         | 80.37         | 80.43          | 80.58         | 81.45    | 81.28         |
| GW-25                   | 85.99                                | 80.39         | 79.83         | 79.83         | 81.05          | 80.02         | 80,59    | 80.73         |
| GW-26                   | 84.96                                | 80.91         | 80.13         | 80.13         | 80.32          | 80,27         | 81.16    | 81.24         |
| GW-27S                  | 89.40                                | 81.15         |               |               | 80.18          | 80.31         | 81.58    | 81 <b>.78</b> |
| GW-27D                  | 89.40                                | 81.24         | -             |               | 80.04          | 80.15         | 81.45    | 81.64         |
| GW-285                  | 85.57                                | 82.86         | 81.12         | 81.12         | 81.36          | 81.30         | 83.45    | 83.50         |
| GW-28D                  | 84.81                                | 82.81         | 81.11         | 81.11         | 81.35          | 81.33         | 83.41    | 83.46         |
| GW-29S                  | 84.27                                | 81.56         | 80.37         | 80.37         | 81.93          | 81.71         | 83.04    | 82.97         |
| GW-29D                  | 84.58                                | 81.36         | 80.23         | 80.23         | 80.30          | 80.38         | 81.56    | 81.69         |
| GW-30DR                 | 89.32                                | 80.06         | 79.12         | 79.12         | _              | 79.28         | 80.35    | 80.65         |
| GW-31S                  | 91.41                                | 81.12         | 80.23         | 80.23         | 80.27          | 80.29         | 81.66    | 82.30         |
| GW-31D                  | 91.68                                | 81.23         | 80.63         | 80.26         | 80.34          | 80.36         | 81.63    | 82.09         |
| GW-32S                  | 87.74                                | 80.18         | 79.34         | 78.69         | 78.83          | 78.82         | 80.68    | 81.56         |
| GW-32D                  | 89.20                                | 81.16         | 80.60         | 80.25         | 80.27          | 80.28         | 81.58    | 82.05         |
| GW-33S                  | 89.88                                | 81.50         | 80.73         | 80.33         | 80.43          | 80.53         | 81.80    | 82.14         |
| GW-33D                  | 89.64                                | 81.54         | 80.79         | 80.39         | 80.45          | 80.55         | 81.80    | 82.14         |
| GW-34S                  | 90.21                                | 81.47         | 80.71         | 80.36         | 80.41          | 80.50         | 81.79    | 82,10         |
| GW-34D<br>GW-356        | 90.27                                | 81.32         | 80.72         | 80.22         | 80.34          | 80.46         | 81.63    | 81.90         |
|                         | 89.57<br>80.74                       | 81.48         | 80.82         | 80.27         | 80.21          | 80.55         | 81.77    | 82.15         |
| GW-35D<br>GW-36         | 89.76<br>85.77                       | 81.41         | 80.81         | 80.31         | 80.46          | 80.64         | 81.72    | 81.95         |
|                         | 85,77<br>83 E1                       | 81.06         | 80.62         | 80.17         | 80.37          | 80.36         | 81.49    | 81.62         |
| GW-37                   | 83.51                                | 81.01         | 80.56         | 80.06         | 80.22          | 80.29         | 81.30    | 81.44         |
| GW-38                   | 86.95                                | 78.76         | 80.35         | 79.85         | 80.07          | 80.09         | 81.13    | 81.21         |
| GW-39                   | 83.55                                | 80,66         | 80.40         | 79.40         | 80.13          | 79.68         | 80.95    | 80.88         |

TABLE 4.6

# SUMMARY OF GROUNDWATER ELEVATIONS WILMINGTON FACILITY

Water Level (ft AMSL)

|                         |                                      |               |               | Wat           | er Level (ft A | MSL)           |                |               |
|-------------------------|--------------------------------------|---------------|---------------|---------------|----------------|----------------|----------------|---------------|
| Monitoring<br>Well I.D. | Top of Casing<br>Elevation (ft AMSL) | 09/30/91      | 02/11/92      | 07/22/92      | 08/14/92       | 09/03/92       | 01/07/93       | 04/21/93      |
| GW Monitorin            | g Wells                              |               |               |               |                |                |                |               |
| GW-40D                  | 88.00                                | 78.28         | 79.05         | 77.80         | 77.42          | 77.34          | 80.15          | 82.28         |
| GW-40S                  | 88.46                                | <b>78.5</b> 6 | 79.31         | 78.08         | 77.62          | <i>77.</i> 53  | 80.34          | 83.14         |
| GW-42D                  | 84.17                                | 80.27         | 79.67         | 79.72         | 80.80          | 80.23          | 80.94          | 81.18         |
| GW-425                  | 84.16                                | 80.71         | 80.26         | 80.01         | 80.36          | 80.12          | 80.90          | 81.00         |
| GW-43D                  | 87.97                                | 80.79         | 80,37         | 79.98         | 80.35          | 80.26          | 81.01          | 81.15         |
| GW-43S                  | <b>87.3</b> 6                        | 81.00         | 80.56         | 80.16         | 80.31          | 80.40          | 81.14          | 81.30         |
| GW-44D                  | 83.97                                |               | 80.42         | 78.47         | 78.03          | 78.88          | 80.34          | 80.57         |
| GW-44S                  | 85.70                                |               | 80.55         | 81.87         | 80.31          | 80.22          | 81.19          | 81.33         |
| GW-45D                  | 89.36                                | -             | 80,51         | 80.15         | 80.46          | 80.24          | 81.18          | 81.31         |
| GW-45S                  | 89.43                                | -             | 80.50         | 80.15         | 81.28          | 80,15          | 81.18          | ***           |
| GW-46D                  | 85.90                                | <u></u>       | 81.35         | 80.75         | 81. <b>7</b> 5 | 80.59          | 82.52          | 82.43         |
| GW-47                   | 93.18                                | 83.26         | 80.53         |               | 78.98          | 79.89          | 84.06          | 84.36         |
| GW-48D                  | 90.86                                | 79.71         | 79.31         | 79.21         | 79.40          | 79.21          | 80.21          | 81.42         |
| GW-48S                  | 91.14                                | 79.86         | <b>79.</b> 19 | 79.23         | 79.51          | 79.13          | 80.34          | 81.52         |
| GW-49D                  | 81.37                                | <del></del>   |               | 74.82         | 75 <b>.3</b> 5 | 74. <b>7</b> 8 | 76.30          | 76.25         |
| GW-50D                  | 80.11                                | 76.34         | 75.96         | 75.16         | 75.55          | 75 <b>.3</b> 5 | 76.89          | <b>76</b> .87 |
| GW-505                  | 79.71                                | 76.41         | _             | 75.36         | 75.74          | 75,51          | 76.92          | 76.87         |
| GW-51D                  | 84.52                                | 78.07         | 77.72         | 76.77         | 76.96          | 76.91          | 78.66          | 78.75         |
| GW-51S                  | 84.59                                | 78.99         | 78.34         | <i>7</i> 7.15 | 77.34          | <i>7</i> 7.31  | 79 <i>.77</i>  | 79.80         |
| GW-52D                  | 88.00                                | 79.40         | 79.00         | 78.35         | 78.38          | 78.55          | 79.78          | 80.30         |
| GW-52S                  | 87.99                                | 80.08         | 78.99         | 78.24         | <b>78.2</b> 5  | 78.44          | 80.13          | 80.45         |
| GW-53D                  | 91.88                                | 83.74         | 84.38         | 84.08         | 84.48          | 84.60          | 86.43          | 87.07         |
| GW-53S                  | 90.69                                | 83.14         | 81.54         | 81.74         | 82.39          | 81.83          | 83.84          | 84.39         |
| GW-54D                  | 89.15                                | 84.21         | 83.15         | 83,05         | 83.57          | 83.21          | 84.83          | 84.96         |
| GW-54S                  | 88.69                                | 84.34         | 83.24         | 83.34         | 84.05          | 83.47          | 85.16          | 84.92         |
| GW-55D                  | 81.73                                | 79.85         |               | 78.34         | 79.03          | 78.68          | 80.08          | 80.05         |
| GW-55S                  | 81.44                                | <b>79</b> .95 | -             | 78.28         | 78.95          | 78.59          | 79.94          | <b>79.9</b> 5 |
| GW-56D                  | 82.76                                | 77.42         | <i>7</i> 7.16 | 75.71         | <i>7</i> 5.81  | <b>7</b> 5.67  | 77.97          | 77.95         |
| GW-56S                  | 83.01                                | 77.47         | 77.16         | 75.72         | 75.82          | 75.69          | 77.99          | 77.99         |
| GW-57D                  | 94.99                                |               | 80.64         | 80.28         | 80.32          | 80.29          | 81.33          | 81.57         |
| GW-58D                  | 98.19                                | <del></del>   |               |               | 80.29          | 80.21          | 81.15          | 81.26         |
| GW-58S                  | 98.21                                |               |               |               | 80.28          | 80.23          | 81.16          | 81.29         |
| GW-59D                  | 85.06                                | _             | 80.46         | 80.35         | 80.49          | 80.40          | 81.46          | 81.56         |
| GW-59S                  | 85.08                                | ***           | 80.68         | 80.28         | 80.41          | 80,36          | 81.31          | 81.45         |
| GW-60D                  | 90.73                                | -             | _             | 80.31         | 80.44          | 80.36          | 81.38          | 81.49         |
| GW-60S                  | 90.48                                |               | ranno         | 80,40         | 80.50          | 80.44          | 81.56          | 81.71         |
| GW-61D                  | 83.66                                |               |               | 79.83         | 79.99          | 79.85          | 80.71          | 80.80         |
| GW-61S                  | 83.51                                |               |               | 79.60         | 79.81          | 79.70          | 80.47          | 80.49         |
| GW-61BR                 | 83.67                                | ****          | _             | *****         | -              |                | 80.87          | 80.94         |
| GW-62D                  | 83.84                                |               | -             | 80.22         | 80.33          | 80.26          | 81.12          | 81.21         |
| GW-62S                  | 84.61                                |               | _             | 80.20         | 80.33          | 80.28          | 81.10          | 81.20         |
| GW-62M                  | 84.38                                |               | -             | 80.22         | 80.34          | 80.28          | 81.13          | 81.21         |
| GW-62BR                 | 83.70                                | w-a-          |               | ~~            | 79.86          | 80.06          | 80,85          | 80.96         |
| GW-62BRD                | 83.66                                |               |               |               |                |                | 80.97          | 80.84         |
| GW-63D                  | 83.32                                |               |               |               | 77.62          | 76.17          | 78.82          | 78.69         |
| GW-63S                  | 82.82                                |               | _             | ***           | 77.64          | 76.19          | 78. <b>7</b> 5 | 78.64         |
| GW-64D                  | 85.96                                |               |               |               | 77.08          | <b>77.</b> 17  | 79.51          | 79.49         |
| GW-64S                  | 86.70                                |               |               |               | 76.70          | 76.79          | 79.45          | 79.43         |
| GW-65D                  | 84.19                                |               |               | -             | 76.83          | 76.55          | 79.39          | 79.31         |
| GW-658                  | 84.14                                | -             |               |               | 78.30          | 77.81          | 79.56          | 79.52         |
|                         |                                      |               |               |               |                |                |                |               |

TABLE 4.6

# SUMMARY OF GROUNDWATER ELEVATIONS WILMINGTON FACILITY

Water Level (ft AMSL)

| 36                      | To a contract                        |          |          | wat           | er Level () i A | MSL)               |             |          |
|-------------------------|--------------------------------------|----------|----------|---------------|-----------------|--------------------|-------------|----------|
| Monitoring<br>Well I.D. | Top of Casing<br>Elevation (ft AMSL) | 09/30/91 | 02/11/92 | 07/22/92      | 08/14/92        | 09/03/92           | 01/07/93    | 04/21/93 |
| GW Monitorin            | g Wells                              |          |          |               |                 |                    |             |          |
| GW-66D                  | 90.32                                |          |          | **            | 80.34           | 80.25              | 81.18       | 81.29    |
| GW-66S                  | 90.15                                |          |          | -             | 80.32           | 80.24              | 81.18       | 81.29    |
| GW-67D                  | 100.39                               | ***      |          |               |                 |                    | 81.07       | 81.24    |
| GW-67S                  | 100.61                               |          |          | <del>*-</del> |                 |                    | 81.13       | 81.28    |
| GW-68D                  | 90.16                                |          |          |               | 81.11           | 80.55              | 82.57       | 82.66    |
| GW-68BR                 | 89.93                                |          |          | ***           |                 |                    | 83.26       | 83.33    |
| GW-69D                  | 93.05                                |          |          |               | 80.22           | 80.16              | 81.14       | 81.27    |
| GW-69S                  | 92.28                                |          |          |               | 80.22           | 80.17              | 81.13       | 81.27    |
| GW-70D                  | 92.10                                | *        |          |               | 80.36           | 80.22              | 81.22       | 81.37    |
| GW-70S                  | 91,99                                |          |          |               | 80.14           | 80.24              | 81.22       | 81.34    |
| GW-71D                  | 96.65                                |          |          |               |                 |                    | 81.24       | 81.32    |
| GW-71S                  | 95.60                                | ***      |          |               |                 |                    | 81.29       | 81.39    |
| GW-72D                  | 88.19                                |          |          | r-r-          |                 |                    |             | 79.96    |
| GW-73D                  | 83.49                                |          | _        |               |                 |                    |             | 79.43    |
| GW-73S                  | 83.39                                |          |          |               |                 |                    |             | 79.51    |
| GW-74D                  | 77.22                                |          |          |               |                 | -                  |             | 73.11    |
| GW-74S                  | 77.43                                |          |          |               |                 |                    | <del></del> | 73.12    |
| GW-75D                  | 83.49                                |          |          |               |                 |                    |             |          |
| GW-758                  | 83.28                                |          |          |               |                 |                    |             |          |
| Sulfate Landfill        | Monitoring Wells                     |          | •        |               |                 |                    |             |          |
| SL1S                    | 86.47                                | 80.65    | _        | 79.42         | 79.13           | 79.09              | 82.15       | 83.06    |
| SL1D                    | 86.44                                | 80.48    |          | 79.38         | 79.09           | 79.06              | 82.14       | 83.15    |
| SL2                     | 85.80                                | 78.94    |          | 78.45         |                 | 77.99              | 80.90       | 83.93    |
| SL3                     | 92.64                                | 78.14    |          | 78.18         |                 | 77.61              | 80.53       | 83.87    |
| SL4                     | 103.19                               | DRY      |          | DRY           |                 | DRY                | DRY         | DRY      |
| SL5                     | 94.41                                | 78.04    | ***      | DRY           |                 | DRY                | 81.41       | 81.85    |
| SL6                     | 92.71                                | 78.09    |          | 77.62         | 76.71           | 76. <del>9</del> 6 | 81.76       | 82.00    |
| SL7                     | 95.25                                | 84.02    |          |               | <b>-</b>        | DRY                | 84,07       | 84.04    |
| SL8                     | 92.42                                | DRY      | ***      |               | B-0             | DRY                | 87.75       | 86.40    |
| Other Plant W           | ells                                 |          |          |               |                 |                    |             |          |
| GT4S                    | 86.39                                | 81.24    | 80.59    |               |                 | 80.32              | 81.57       | 81.65    |
| GT4D                    | 88.51                                | 81.26    | 80.71    |               |                 | 80.47              | 81.65       | 81.83    |
| GT5                     | 88.03                                | 81.28    | 80.73    | ***           | 80.36           | 80.42              | 81.65       | 81.84    |
| GT6S                    | 87.40                                | 81.43    | 80.90    |               |                 | 80.61              | 81.90       | 82.08    |
| GT6D                    | 87.25                                | 81.27    | 80.75    | ***           |                 | 80.46              | 81.65       | 81.83    |
| GT7                     | 90.51                                |          | 81.41    | 80.76         |                 | 81.39              | 82.84       |          |
| GT9S                    | 86.97                                | 81.44    | 80.77    | 80.27         | 80.39           | 80.51              | 81.72       | 81.99    |
| GT9D                    | 87.62                                | 81.42    | 80.82    | 80.27         | 80.39           | 80.50              | 81.72       | 81.99    |
| 00                      |                                      |          |          |               |                 |                    |             |          |
| 98                      | 87.22                                | 79.08    | 78.87    | 78.27         |                 | 78.39              | 79.57       |          |
| 99<br>Tazzo             | 90.81                                |          | 80.01    | 79.46         |                 | 79.59              | DRY         | 81.14    |
| IW10                    | .90.34                               |          | 18-ii    |               | طبطت            | 77.51              | DRY         | 78.05    |

Notes:

ft AMSL - feet Above Mean Sea Level

TABLE 4.7

PIEZOMETRIC GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

|                    | Top of<br>Piezometer/<br>Staff Gauge |               |   |               |               |                  |                        | <u></u>               |          |
|--------------------|--------------------------------------|---------------|---|---------------|---------------|------------------|------------------------|-----------------------|----------|
| Location<br>I.D.   | Elevation<br>(ft AMSL)               |               | Surface Wat<br>(ft Al                   | er Elevation  |               |                  | Groundwat<br>(ft Al    | er Elevation<br>MSI ) |          |
| 1.17.              | () LAWSL)                            | 07/22/92      | 09/03/92                                | 01/07/93      | 04/21/93      | 07/22/92         | 09/03/92               | 01/07/93              | 04/21/93 |
| <u>Piezometers</u> |                                      |               | *************************************** |               |               |                  |                        |                       | -        |
| PZ-1               | 80.68                                | <i>7</i> 9.55 | <b>7</b> 9.60                           | 79.64         | 80.20         | 79.64            | <b>7</b> 9. <b>7</b> 9 | 79.86                 | 80.28    |
| PZ-2               | 80.41                                | 79.37         | <b>7</b> 9.59                           | <b>7</b> 9.61 | 80.22         | <b>7</b> 9.47    | 79.66                  | 79.69                 | 80.23    |
| PZ-3               | 80.1                                 | 79.16         | 79.58                                   | ·             |               | 79.33            | 79.64                  | ***                   | سد ديد.  |
| PZ-4               | 80.19                                | 79.34         | 79.57                                   | 79.64         |               | 79.47            | <i>7</i> 9. <i>7</i> 0 | 79.79                 | obs mer  |
| PZ-5               | 80.58                                | 79.45         | <i>7</i> 9.56                           | 79.65         | 80.15         | <i>7</i> 9.54    | 79.73                  | <b>7</b> 9.89         | 80.36    |
| PZ-6               | 81.01                                | <i>7</i> 9.53 | 79.63                                   | 79.78         | 80.23         | 79.76            | 80.03                  | 80.39                 | 80.61    |
| PZ-7               | 81.09                                | 79.67         | <b>7</b> 9.68                           | <i>7</i> 9.35 | 80.22         | 79.78            | 79.97                  | 80.15                 | 80.41    |
| PZ-8               | 81.42                                |               | 82.24                                   | *****         | 80.23         | <del>limit</del> | 80.04                  | ****                  | 80.47    |
| PZ-9               | 80.64                                | <b>7</b> 9.09 | 79.59                                   | 79.60         | 80.19         | 79.15            | 79.62                  | 79.63                 | 80.26    |
| PZ-10              | 81.63                                | 78.91         | 78.97                                   | <i>7</i> 9.21 | <i>7</i> 9.17 | <b>7</b> 9.21    | 79.04                  | 79.52                 | 79.62    |
| Staff Gauges       |                                      |               |   |               |               |                  |                        |                       |          |
| MMB-PZ1            | 82.60                                | ****          |   |               | 81.89         | -                |                        | -                     | Wan      |
| MMB-PZ2            | 81.89                                | M             |   | ****          | 80.63         |                  |                        |                       | ***      |

ft AMSL - feet Above Mean Sea Level

TABLE 4.8

GROUNDWATER INDICATOR SAMPLING SUMMARY(1)

WILMINGTON FACILITY

|            | Date       |                | Date              |
|------------|------------|----------------|-------------------|
| Monitoring | Sampled    | Monitoring     | Sampled           |
| Well ID    | (mm/dd/yy) | Well ID        | (mm/dd/yy)        |
|            |            |                |                   |
| GW-3D      | 08/01/91   | GW-45S         | 02/08/92          |
| GW-3S      | 08/01/91   | GW-45D         | 12/13/92          |
| GW-4S      | 08/01/91   | GW-46D         | 02/08/92          |
| GW-4D      | 08/01/91   | GW-47          | 08/01/91          |
| GW-10D     | 08/01/91   | GW-48D         | 08/01/91          |
| GW-10S     | 08/01/91   | <b>GW-4</b> 8S | 08/01/91          |
| GW-11S     | 08/01/91   | GW-50D         | 08/01/91          |
| GW-12S     | 08/01/91   | GW-50S         | 08/01/91          |
| GW-17D     | 08/01/91   | GW-51D         | 08/01/91          |
| GW-17S     | 08/01/91   | GW-51S         | 08/01/91          |
| GW-18D     | 08/01/91   | GW-52D         | 08/01/91          |
| GW-21D     | 08/01/91   | GW-52S         | 08/01/91          |
| GW-21S     | 08/01/91   | GW-53D         | 08/01/91          |
| GW-24S     | 08/01/91   | GW-53S         | 08/01/91          |
| GW-25S     | 08/01/91   | GW-54D         | 08/01/91          |
| GW-26S     | 08/01/91   | <b>GW-54</b> S | 08/01/91          |
| GW-28D     | 08/01/91   | GW-55D         | 08/01/91          |
| GW-28S     | 08/01/91   | GW-55S         | 08/01/91          |
| GW-29D     | 08/01/91   | GW-56D         | 08/01/91          |
| GW-29S     | 08/01/91   | GW-56S         | 08/01/91          |
| GW-36D     | 08/01/91   | GW-57D         | 02/08/92,05/13/92 |
| GW-37D     | 08/01/91   | GW-59D         | 02/08/92          |
| GW-38D     | 08/01/91   | GW-59S         | 02/08/92          |
| GW-39D     | 08/01/91   | GW-60D         | 05/13/92          |
| GW-40D     | 08/01/91   | GW-60S         | 05/13/92          |
| GW-40S     | 08/01/91   | GW-61D         | 05/12/92          |
| GW-42D     | 08/01/91   | GW-61S         | 05/13/92          |
| GW-42S     | 08/01/91   | GW-62D         | 05/12/92          |
| GW-43D     | 08/01/91   | GW-62M         | 05/12/92          |
| GW-43S     | 08/01/91   | GW-62S         | 05/12/92          |
| GW-44D     | 01/27/92   |                | ,                 |

<sup>(1)</sup> Indicator parameters include chloride, chromium, ammonia and sulphate.

TABLE 4.9

FULL GROUNDWATER TCL/TAL PARAMETER SAMPLING SUMMARY (1)

WILMINGTON FACILITY

| Monitoring<br>Well ID | Date<br>Sampled<br>(mm/dd/yy) |
|-----------------------|-------------------------------|
| vveil 11)             | (ninuanyy)                    |
| IW-11                 | 12/17/91                      |
| GW-27D                | 12/10/91                      |
| GW-31D                | 12/06/91                      |
| GW-35S                | 12/10/91                      |
| GW-36                 | 12/10/91                      |
| GW-40D                | 12/10/91                      |
| GW-42D                | 12/10/91                      |
| GW-50D                | 12/10/91                      |
| GW-54S                | 12/06/91                      |
| GW-55D                | 12/10/91                      |
| SL-05                 | 12/10/91                      |

(1) Samples also analyzed for 2,4,4-Trimethyl-1-Pentene, 2,4,4-Trimethyl-2-Pentene, Ammonia, Chlorides and Sulphates.

# FIRST ROUND GROUNDWATER SAMPLING SUMMARY WILMINGTON FACILITY

### First Round Groundwater Sampling (August 3 - 13, 1992)

| Monitoring<br>Well I.D. | pΗ      | Conductivity<br>(µhmos) | Temperature<br>(°C) | Sample Identification                  | Analysis<br>Parameters |
|-------------------------|---------|-------------------------|---------------------|--|------------------------|
| GW Monitoring           | g Wells |                         |                     |  |                        |
| GW-4                    | 6.1     | 900                     | 14                  | W-920804-JM-029                        | SSPL                   |
| GW-4D                   | 6.2     | 1,300                   | 14                  | W-920804-JM-028                        | SSPL                   |
| <b>G</b> W-6S           |         |                         | ***                 | W-920804-JM-013                        | SSPL                   |
| GW-6D                   | 6.4     | 600                     | 15                  | W-920804-JM-014                        | SSPL                   |
| GW-10S                  | 4.3     | 100                     | 15                  | W-920810-JM-071                        | SSPL                   |
| GW-10D                  | 4.2     | 9,400                   | 14                  | W-920810-JM-059                        | SSPL                   |
| GW-12                   | 5.6     | 200                     | 15                  | W-920810-JM-067                        | SSPL                   |
| GW-17S                  |         |                         |                     | DRY                                    | v+ 4A                  |
| GW-17D                  | 5.5     | 2,350                   | 15                  | W-920805-JM-024                        | SSPL                   |
| GW-18S                  |         |                         | <del></del>         | DRY                                    | 40.00                  |
| GW18D                   | 7.0     | 700                     | 15                  | W-920806-JM-049                        | SSPL                   |
| GW-19D                  | 6.4     | 2,000                   | 15                  | W-920804-JM-015                        | SSPL                   |
| GW-22S                  |         | ****                    |                     | W-920812-JM-109                        | SSPL                   |
| GW-22D                  |         | <del></del>             |                     | W-920812-JM-110                        | SSPL                   |
| GW-25                   | 7.1     | 3,800                   | 13                  | W-920810-JM-068                        | SSPL                   |
| GW-26                   | 6.2     | 900                     | 16                  | W-920810-JM-072                        | SSPL                   |
| GW-27S                  | 6.5     | 2,600                   | 15                  | W-920812-JM-093                        | SSPL and Density       |
| GW-27D                  | 3.7     | >19,900                 | 15                  | W-920812-JM-094                        | SSPL and Density       |
| GW-28S                  | 6.2     | 300                     | 21                  | W-920810-JM-064                        | SSPL                   |
| GW-28D                  | 6.3     | 500                     | 21                  | W-920810-JM-063                        | SSPL                   |
| GW-29S                  | 3.9     | 200                     | 18                  | W-920810-JM-061                        | SSPL                   |
| GW-29D                  | 6.1     | 3,000                   | 16                  | W-920810-JM-060                        | SSPL                   |
| GW-30DR                 | 4.0     | >50,000                 | 20                  | W-920803-JM-020                        | SSPL                   |
| GW-31S                  | 6.5     | 295                     | 17.5                | W-920803-JM-002                        | SSPL                   |
| GW-31D                  | 6.8     | 400                     | 15                  | W-920803-JM-001                        | SSPL                   |
| GW-32S                  | 6.1     | 335                     | 17                  | W-920803-JM-004                        | SSPL                   |
| GW-32D                  | 7.0     | 1,550                   | 16.5                | W-920803-JM-003                        | SSPL                   |
| GW-33S                  | 6.6     | 255                     | 16.5                | W-920803-JM-007                        | SSPL                   |
| GW-33D                  | 6.8     | 700                     | 17                  | W-920803-JM-008                        | SSPL                   |
| GW-34S                  | 6.8     | 130                     | 17                  | W-920804-JM-010                        | SSPL                   |
| GW-34D                  | 4.6     | 4,300                   | 16                  | W-920804-JM-009                        | SSPL                   |
| GW-35S                  | 6.5     | 1,600                   | 18                  | W-920804-JM-012                        | SSPL                   |
| GW-35D                  | 4.0     | >50,000                 | 18                  | W-920804-JM-011                        | SSPL                   |
| GW-36                   | 3.5     | >19,900                 | 13                  | W-920811-JM-082                        | SSPL and Hex           |
| GW-37                   | 3.5     | >19,900                 | 13                  | W-920811-JM-083                        | SSPL and Hex           |
| GW-38                   | 4.1     | 28,000                  | 18                  | W-920804-JM-021                        | SSPL                   |
| GW-39                   | 6.0     | 800                     | 17                  | W-920806-JM-058                        | SSPL                   |
| GW-40D                  | 9.0     | 2,400                   | 13                  | W-920811-JM-084/085 DUP/086 MS/087 MSD | SSPL and Density       |
| GW-40S                  | 4.9     | 100                     | 16                  | W-920811-JM-088                        | SSPL                   |
| GW-42D                  | 3.7     | >50,000                 | 20                  | W-920805-JM-025/026 DUP/033 MS/032 MSD | SSPL, Hex and Density  |

# FIRST ROUND GROUNDWATER SAMPLING SUMMARY WILMINGTON FACILITY

### First Round Groundwater Sampling (August 3 - 13, 1992)

| Monitoring<br>Well I.D. | pH          | Conductivity<br>(µhmos) | Temperature<br>(°C) | Sample Identification                  | Analysis<br>Parameters |
|-------------------------|-------------|-------------------------|---------------------|--|------------------------|
| GW-42S                  | 5.3         | 220                     | 19                  | W-920805-JM-027                        | SSPL                   |
| GW-43D                  | 4.3         | 24,000                  | 18                  | W-920805-JM-036/037 DUP                | SSPL, Hex and Density  |
| GW-43S                  | 6.0         | 300                     | 15                  | W-920805-JM-038                        | SSPL and Density       |
| GW-44D                  | 3.5         | 41,000                  | 20                  | W-920812-JM-108                        | SSPL, Hex and Density  |
| GW-44S                  | <i>7</i> .1 | 200                     | 17                  | W-920812-JM-107                        | SSPL and Density       |
| GW-45D                  | 3.4         | >10,000                 |                     | W-920810-JM-062                        | SSPL, Hex and Density  |
| GW-45S                  | 6.2         | 390                     |                     | W-920810-JM-046                        | SSPL                   |
| GW-46D                  | 6.9         | 200                     | 12.5                | W-920811-JM-075                        | SSPL                   |
| GW-47                   |             | 140 MA                  | ***                 | W-920813-JM-113                        | SSPL                   |
| GW-48D                  | 5.8         | 100                     | 11                  | W-920812-JM-092/090 MS/089MSD          | SSPL                   |
| GW-48S                  | 4.6         | 100                     | 13                  | W-920812-JM-091                        | SSPL                   |
| GW-49D                  | 6.1         | 700                     | 15                  | W-920812-JM-104                        | SSPL                   |
| GW-50D                  | 6.1         | 10,500                  | 12                  | W-920805-JM-030/031 DUP/034 MS/035 MSD | SSPL                   |
| GW-50S                  | 5.8         | 2,200                   | 13.0                | W-920806-JM-045                        | SSPL and Density       |
| GW-51D                  | 5.9         | 1,000                   | 12                  | W-920805-JM-022                        | SSPL                   |
| GW-51S                  | 5.1         | 700                     | 13                  | W-920805-JM-023                        | SSPL                   |
| GW-52D                  |             |                         | -                   | W-920804-JM-019                        | SSPL                   |
| GW-52S                  | 7.8         | 800                     | 17                  | W-920804-JM-018                        | SSPL                   |
| GW-53D                  | 6.4         | 390                     | 16                  | W-920804-JM-016                        | SSPL                   |
| GW-53S                  | 6.8         | 120                     | 20                  | W-920804-JM-017                        | SSPL                   |
| GW-54D                  | 5.8         | 400                     | 20                  | W-920803-JM-006                        | SSPL                   |
| GW-54S                  | 6.5         | <b>29</b> 0             | 20                  | W-920805-JM-005                        | SSPL                   |
| GW-55D                  | 5.7         | 11,500                  | 16                  | W-920805-JM-042/039 MS/040 MSD         | SSPL                   |
| GW-55S                  | 6.3         | 4,100                   | 18                  | W-920805-JM-041                        | SSPL                   |
| GW-56D                  | 5.7         | 1,100                   | 14                  | W-920806-JM-047                        | SSPL                   |
| GW-56S                  | 4.8         | 600                     | 15                  | W-920806-JM-048                        | SSPL                   |
| GW-57D                  | 6.2         | 450                     | 15                  | W-920806-JM-051/052 MS/053 MSD         | SSPL                   |
| GW-58D                  | 6.1         | 5,300                   |                     | W-920811-JM-079                        | SSPL, Hex and Density  |
| GW-58S                  | <b>7</b> .1 | 340                     |                     | W-920811-JM-078                        | SSPL and Density       |
| GW-59D                  | 4.1         | 35,000                  | 20                  | W-920806-JM-056/055 DUP                | SSPL, Hex and Density  |
| GW-59 <b>S</b>          | 6.0         | 650                     | 19                  | W-920806-JM-054                        | SSPL and Density       |
| GW-60D                  | 6.6         | 200                     | 17                  | W-920811-JM-081                        | SSPL                   |
| GW-60S                  | 6.4         | 300                     | 20                  | W-920811-JM-080                        | SSPL                   |
| GW-61D                  | 6.2         | 500                     | 13                  | W-920812-JM-096                        | SSPL                   |
| GW-61S                  | 5.9         | 300                     | 13                  | W-920812-JM-095                        | SSPL                   |
| GW-62D                  | 6.3         | 500                     | 13                  | W-920811-JM-074                        | SSPL                   |
| GW-62S                  | 6.0         | 300                     | 15                  | W-920811-JM-073                        | SSPL                   |
| GW-62M                  | <b>6</b> .6 | 200                     | 12                  | W-920811-JM-106                        | SSPL                   |
| GW-62BR                 | 6.7         | 6,800                   | 14                  | W-920813-JM-114                        | SSPL and Density       |
| GW-63D                  | 7.3         | 340                     |                     | W-920812-JM-097                        | SSPL                   |
| GW-63S                  | <i>7</i> .5 | 310                     | ***                 | W-920812-JM-098                        | SSPL                   |
| GW-64D                  | 6.5         | 700                     | 12                  | W-920812-JM-100/101 DUP                | SSPL                   |

# FIRST ROUND GROUNDWATER SAMPLING SUMMARY WILMINGTON FACILITY

### First Round Groundwater Sampling (August 3 - 13. 1992)

| Monitoring<br>Well I.D. | pН        | Conductivity<br>(µhmos) | Temperature<br>(°C) | Sample Identification | Analysis<br>Parameters |
|-------------------------|-----------|-------------------------|---------------------|-----------------------|------------------------|
| GW-64S                  | 5.8       | 200                     | 18                  | W-920812-JM-099       | SSPL                   |
| GW-65D                  | 6.5       | 300                     | 12                  | W-920813-JM-111       | SSPL                   |
| GW-65S                  | 6.4       | 300                     | 13                  | W-920813-JM-112       | SSPL                   |
| GW-66D                  | 7.1       | 300                     | _                   | W-920811-JM-077       | SSPL                   |
| GW-66S                  | 7.1       | 200                     | -                   | W-920811-JM-076       | SSPL                   |
| GW-68D                  | 6.1       | 450                     | 17                  | W-920806-JM-050       | SSPL                   |
| GW-69D                  | 4.2       | 14,500                  | 16                  | W-920806-JM-044       | SSPL                   |
| GW-69S                  | 5.8       | 200                     | 17.5                | W-920806-JM-043       | SSPL                   |
| GW-70D                  | 5.5       | >10,000                 |                     | W-920810-JM-069       | SSPL                   |
| GW-70S                  | 6.5       | 350                     | _                   | W-920810-JM-070       | SSPL                   |
| Sulfate Landfill        | Monitorin | g Wells                 |                     |                       |                        |
| SL1S                    | 5.2       | 100                     | 18                  | W-920810-JM-065       | SSPL                   |
| SL1D                    | 5.2       | 200                     | 17                  | W-920810-JM-066       | SSPL                   |
| SL6                     | 5.4       | 2,000                   | 18                  | W-920806-JM-057       | SSPL                   |
| Other Plant We          | Ils       |                         |                     |                       |                        |
| В-3                     |           | *****                   | <del></del>         | W-920812-JM-103       | SSPL                   |
| IW-4                    |           |                         | ***                 | W-920812-JM-102       | SSPL                   |
| IW-11                   | ***       |                         |                     | W-920812-JM-105       | SSPL                   |

### Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate. Hex analysis parameter is hexavalent chromium

Duplicate (DUP)

Matrix Spike (MS)

Matrix Spike Duplicate (MSD)

**TABLE 4.11** 

## SECOND ROUND GROUNDWATER SAMPLING SUMMARY WILMINGTON FACILITY

(1)

## Second Round Groundwater Sampling (November 3 - 19, 1992)

| Monitoring<br>Well I.D. | pН          | Conductivity<br>(µmhos) | Temperature<br>(°C) | Sample Identification                  | Analysis<br>Parameters |
|-------------------------|-------------|-------------------------|---------------------|--|------------------------|
| GW Monitoris            | ng Wells    |                         |                     |  |                        |
| GW-3S                   | 6.2         | 267                     | 11.2                | W-921105-JM-035                        | SSPL                   |
| GW-3D                   | 6.4         | 624                     | 10.1                | W-921105-JM-034                        | SSPL                   |
| GW-4S                   | 6.2         | 5 <b>7</b> 8            | 11.9                | W-921105-JM-043                        | SSPL                   |
| GW-4D                   | 6.3         | 699                     | 11.4                | W-921105-JM-042                        | SSPL                   |
| GW-6S                   | 6.5         | 464                     | 12.5                | W-921103-JM-022                        | SSPL                   |
| GW-6D                   | 6.7         | 464                     | 11.5                | W-921103-JM-021                        | SSPL                   |
| GW-10S                  | 5.1         | 165                     | 11.4                | W-921112-JM-094                        | SSPL                   |
| GW-10D                  | 5.1         | 5,670                   | 9.7                 | W-921109-JM-061                        | SSPL                   |
| GW-11                   | 6.6         | 2,070                   | 10.8                | W-921109-JM-059                        | SSPL                   |
| GW-12                   | 6.6         | 114                     | 12.0                | W-921111-JM-074                        | SSPL                   |
| GW-17S                  | 6.7         | 686                     | 10.8                | W-921103-JM-018                        | SSPL                   |
| GW-17D                  | 5.5         | 1,880                   | 1 <b>1</b> .3       | W-921103-JM-017                        | SSPL                   |
| GW-18S                  |             |                         |                     | Dry                                    | SSPL                   |
| GW-18D                  | 7.1         | 6 <b>7</b> 3            | 8.1                 | W-921109-JM-056                        | SSPL                   |
| GW-19D                  | 6.8         | 1,340                   | 10.0                | W-921109-JM-050/053 DUP/051 MS/052 MSD | SSPL                   |
| GW-21S                  | 6.9         | 314                     | 13.1                | W-921106-JM-044                        | SSPL                   |
| GW-21D                  | 7.0         | 235                     | 12.4                | W-921106-JM-045                        | SSPL                   |
| GW-22S                  | 6.8         | 819                     | <b>13.7</b>         | W-921105-JM-038                        | SSPL                   |
| GW-22D                  | 4.1         | 21,400                  | 11.4                | W-921105-JM-039                        | SSPL                   |
| GW-25                   | 7.3         | 1,293                   | 11.4                | W-921116-JM-108                        | SSPL                   |
| GW-26                   | 6.54        | 410                     | 11 <i>.7</i>        | W-921116-JM-099                        | SSPL                   |
| GW-27S                  | 7.1         | 1,987                   | 11.5                | W-921109-JM-057                        | SSPL and Density       |
| GW-27D                  | 4.4         | 15,200                  | 10.0                | W-921109-JM-058                        | SSPL and Density       |
| GW-28S                  | 5 <i>.7</i> | 3 <b>44</b>             | 11.5                | W-921106-JM-049                        | SSPL                   |
| GW-28D                  | 6.8         | 416                     | 11.6                | W-921106-JM-048                        | SSPL                   |
| GW-29S                  | 5. <i>7</i> | 270                     | 10.6                | W-921106-JM-046                        | SSPL                   |
| GW-29D                  | 6.4         | 1,850                   | 10.2                | W-921106-JM-047                        | SSPL                   |
| GW-30DR                 | 4.2         | 26,300                  | 10.3                | W-921109-JM-062                        | SSPL                   |
| GW-31S                  | 6.5         | 205                     | -                   | W-921102-JM-001                        | SSPL                   |
| GW-31D                  | 6.7         | 305                     | -                   | W-921102-JM-002                        | SSPL                   |
| GW-32S                  | <i>7</i> .0 | 105                     |                     | W-921102-JM-003                        | SSPL                   |
| GW-32D                  | 6.8         | 237                     | •••                 | W-921102-JM-004                        | SSPL                   |
| GW-33S                  | <i>7.</i> 0 | NT                      | NT                  | W-921103-JM-019                        | SSPL                   |
| GW-33D                  | 7.2         | 503                     | NT                  | W-921103-JM-020                        | SSPL                   |
| GW-34S                  | 6.1         | 150                     | 14.6                | W-921105-JM-040                        | SSPL                   |
| GW-34D                  | 4.8         | 2,850                   | 13.4                | W-921105-JM-041                        | SSPL                   |
| GW-35S                  | 6.7         | 1,490                   | 13.5                | W-921105-JM-037                        | SSPL                   |
| GW-35D                  | 3.8         | 5,940                   | 11.8                | W-921105-JM-036                        | SSPL                   |
| GW-36                   | 4.1         | 27,800                  | 9.9                 | W-921116-JM-101                        | SSPL and Hex           |
| GW-37                   | 4.24        | 26,300                  | 9.6                 | W-921116-JM-100                        | SSPL and Hex           |
| GW-38                   | 4.4         | 12,800                  | 10.4                | W-921109-JM-060                        | SSPL                   |
| GW-39                   | 6.6         | 324                     | 11.2                | W-921111-JM-077                        | SSPL                   |
| GW-40D                  | 9.0         | 1,480                   | 10.4                | W-921111-JM-069/075 MS/076 MSD         | SSPL and Density       |
| GW-40S                  | 5.3         | 86                      | 127                 | W-921111-JM-078                        | SSPL                   |
| GW-42D                  | 3.8         | 36,000                  | 11.5                | W-921111-JM-079/082 DUP/080 MS/081 MSD | SSPL, Hex and Density  |
| GW-425                  | 5.8         | 125                     | 13.2                | W-92111-JM-083                         | SSPL                   |
| GW-43D                  | 4.5         | 1,409                   | 11.0                | W-921111-JM-065/066 DUP                | SSPL, Hex and Density  |
| GW-43S                  | 6.1         | 222                     | 12.7                | W-921111-JM-084                        | SSPL and Density       |

TABLE 4.11

## SECOND ROUND GROUNDWATER SAMPLING SUMMARY WILMINGTON FACILITY

(1)

## Second Round Groundwater Sampling (November 3 - 19, 1992)

| GW-44D         3.2         28,700         10.5         W-921110-JM-063         SSPL, Hex at a constant and separate and | I Density and Density PL PL PL PL PL PL PL PL |
|--|---|
| GW-44S         5.2         156         11.9         W-921110-JM-071         SSPL and GW-45D         4.0         20,700         10.8         W-921112-JM-093         SSPL, Hex at GW-45S         5.7         228         13.1         W-921112-JM-092         SSI         GW-46D         6.6         118         10.6         W-921117-JM-114         SSI         GW-47         6.34         56         12.1         W-921118-JM-128         SSI           GW-48D         6.32         114         10.0         W-921117-JM-115/116 MS/117 MSD         SSI  | I Density and Density PL PL PL PL PL PL PL PL |
| GW-45D         4.0         20,700         10.8         W-921112-JM-093         SSPL, Hex at a constant of the constant of  | PL PL PL PL PL PL PL PL                       |
| GW-45S         5.7         228         13.1         W-921112-JM-092         SSI           GW-46D         6.6         118         10.6         W-921117-JM-114         SSI           GW-47         6.34         56         12.1         W-921118-JM-128         SSI           GW-48D         6.32         114         10.0         W-921117-JM-115/116 MS/117 MSD         SSI   | PL<br>PL<br>PL<br>PL<br>PL                    |
| GW-47 6.34 56 12.1 W-921118-JM-128 SSI<br>GW-48D 6.32 114 10.0 W-921117-JM-115/116 MS/117 MSD SSI  | PL<br>PL<br>PL<br>PL                          |
| GW-48D 6.32 114 10.0 W-921117-JM-115/116 MS/117 MSD SSI  | PL<br>PL<br>PL                                |
| GW-48D 6.32 114 10.0 W-921117-JM-115/116 MS/117 MSD SSI  | PL<br>PL<br>PL                                |
|  | PL<br>PL                                      |
| GW-48S 5.49 72 12.3 W-921117-JM-118 SSI  | PL  |
| GW-49D 6.7 355 13.2 W-921116-JM-102 SSI  |   |
| GW-50D 6.3 7,470 9.8 W-921104-JM-023/025 DUP/024 MS/026 MSD SSI  | 1.75  |
| GW-50S 6.2 1,382 11.2 W-921104-JM-027 SSPL and   | Libensity                                     |
| GW-51D 6.0 1,230 10.6 W-921103-JM-016 SSI  |   |
| GW-51S 6.0 502 11.0 W-921103-JM-015 SSI  | PL  |
| GW-52D 9.3 1,570 12.7 W-921103-JM-010 SSI  | PL.   |
| GW-52S 7.9 662 13.0 W-921103-JM-009 SSI  | PL  |
| GW-53D 6.8 236 15.1 W-921103-JM-011 SSI  | PL  |
| GW-53S 8.1 68 14.2 W-921103-JM-012 SSI   | PL  |
| GW-54D 6.5 257 15.5 W-921103-JM-013 SSI  | PL  |
| GW-54S 6.7 170 14.1 W-921103-JM-014 SSI  | PL  |
| GW-55D 5.9 9,150 11.4 W-921102-JM-006 SSI  |   |
| GW-55S 6.1 3,520 11.1 W-921102-JM-005 SSI  | PL  |
| GW-56D 5.9 404 10.1 W-921102-JM-008 SSI  | PL  |
| GW-56S 5.3 322 10.4 W-921102-JM-007 SSI  | PL  |
| GW-57 6.52 156 10.0 W-921117-JM-110/109 MS/113 MSD SSI   | PL  |
| GW-58D 6.3 3,990 10.9 W-921119-JM-091 SSPL, Hex a  | and Density                                   |
| GW-58S 6.2 224 11.9 W-921112-JM-090 SSPL and   |   |
| GW-59D 3.4 21,600 9.5 W-921110-JM-64/067 DUP SSPL, Hexa  |   |
| GW-59S 5.3 302 13.6 W-921110-JM-070 SSPL and   |   |
| GW-60D 6.7 123 10.6 W-921117-JM-112 SSI  | -   |
| GW-60S 6.8 115 8.7 W-921117-JM-111 SSI   | PL.   |
| GW-61D 6.5 312 9.7 W-921113-JM-096 SSI   |   |
| GW-61S 6.4 167 10.6 W-921113-JM-095 SSI  |   |
| GW-61BR NT 500 NT W-921218-JM-133 SSI  |   |
| GW-62D 6.64 60 9.2 W-921116-JM-103 SSI   |   |
| GW-62S 6.53 49.0 10.9 W-921116-JM-105 SSI  |   |
| GW-62M 6.75 40 8.8 W-921116-JM-104 SSI   |   |
| GW-62BR 7.71 2,940 8.1 W-921119-JM-129 SSPL and  |   |
| GW-62BRD NT NT NT W-930107-JM-134 SSI  |   |
| GW-63D 6.62 236 10.6 W-921118-JM-122 SSI   |   |
| GW-63S 6.49 170 9.3 W-921118-JM-121 SSI  |   |
| GW-64D 6.8 356 8.0 W-921118-JM-127 SSI   |   |
| GW-64S 6.09 125 13.6 W-921118-JM-126 SSI   |   |
| GW-65D 6.8 190 8.8 W-921118-JM-123 SSI   |   |
| GW-65S 6.61 1.0 10.8 W-921118-JM-124/125 DUP SSI   |   |
| GW-66D 6.6 530 9.9 W-921112-JM-089 SSI   |   |
| GW-66S 6.6 146 10.7 W-921112-JM-088 SSI  |   |
| GW-67S 6.6 97 11.1 W-921113-JM-097 SSI   |   |
| GW-67D 6.9 316 10.9 W-921113-JM-098 SSI  |   |
| GW-68BR NT 500 W-921218-JM-133 SSI   |   |
| GW-68 5.9 198 14.9 W-921114-JM-085 SSI   |   |

**TABLE 4.11** 

## SECOND ROUND GROUNDWATER SAMPLING SUMMARY WILMINGTON FACILITY

(1)

## Second Round Groundwater Sampling (November 3 - 19, 1992)

| Monitoring<br>Well I.D. | pН    | Conductivity<br>(µmhos) | Temperature<br>(°C) | Sample Identification | Analysis<br>Parameters |
|-------------------------|-------|-------------------------|---------------------|-----------------------|------------------------|
| GW-69D                  | 4.1   | 7,500                   | 9.2                 | W-921116-JM-106       | SSPL                   |
| GW-69S                  | 5.46  | 117                     | 11.6                | W-921116-JM-107       | SSPL                   |
| GW-70D                  | 5.6   | 1,356                   | 10.4                | W-921112-JM-087       | SSPL                   |
| GW-70S                  | 6.5   | 206                     | 11.5                | W-921112-JM-086       | SSPL                   |
| GW-71S                  | NT    | 100                     | NT                  | W-921217-JM-130       | SSPL                   |
| GW-71D                  | NT    | 500                     | NT                  | W-921217-JM-131       | SSPL                   |
| GW-72D                  | 7.11  | 121                     | 13.1                | W-921117-JM-120       | SSPL                   |
| GW-73D                  | 6.5   | 300                     | 7.0                 | W-930420-MJ-003       | SSPL                   |
| GW-73S                  | 6.4   | 100                     | 7.0                 | W-930420-MJ-004       | SSPL                   |
| GW-74D                  | 6.4   | 400                     | 8.0                 | W-930420-MJ-001       | SSPL                   |
| GW-74S                  | 6.4   | 300                     | 8.0                 | W-930420-MJ-002       | SSPL                   |
| GW-75D                  | 6.8   | 250                     | 10.0                | W-930507-JM-01/MS/MSD | SSPL                   |
| GW-75S                  | 6.8   | 200                     | 8.0                 | W-930507-JM-02        | SSPL                   |
| Sulphate Lan            | dfill |                         |                     | ,                     |                        |
| SL1D                    | 6.3   | 194                     | 12.2                | W-921109-JM-055       | SSPL                   |
| SL6                     | 6.1   | 2,822                   | 11.3                | W-921109-JM-054       | SSPL                   |
| Other Plant             | Wells |                         | ·                   |                       |                        |
| B-3                     | 5.0   | 8.54                    | 12.8                | W-921110-JM-072       | SSPL                   |
| IW-4                    | 5.4   | 4.75                    | 12.5                | W-921110-JM-068       | SSPL                   |
| IW-11                   |       | <del></del>             | - Marie             | W-921110-JM-073       | SSPL                   |
| BR-1                    | 13.31 | 8,590                   | 9.0                 | W-921119-JM-119       | SSPL                   |

## Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

Hex analysis parameter is hexavalent chromium.

Duplicate (DUP).

Matrix Spike (MS).

<sup>(1)</sup> Sampling conducted on monitoring wells installed after November 19, 1992 have been included as part of the Second Round Groundwater Sampling Event.

TABLE 4.12

## FIRST ROUND SURFACE WATER SAMPLING SUMMARY WILMINGTON FACILITY

## First Round Surface Water (August 31 - September 2. 1992)

| Location<br>I.D. | pН            | Conductivity<br>(µhmos) | Temperature<br>(°C) | Sample Identification    | Analysis<br>Parameters |
|------------------|---------------|-------------------------|---------------------|--------------------------|------------------------|
| SW-1             | 7.40          | 318                     | 20.7                | W-920831-JM-120          | SSPL                   |
| SW-2             | 7.52          | 332                     | 21.3                | W-920831-JM-119          | SSPL                   |
| SW-3             | 7.51          | 380                     | 23.2                | W-920831-JM-118          | SSPL                   |
| SW-4             | 7.37          | 381                     | 24.5                | W-920831-JM-117          | SSPL                   |
| SW-5             | 6.22          | 389                     | 25.0                | W-920831-JM-115          | SSPL                   |
| SW-6             | 6.67          | 1,235                   | 20.6                | W-920831-JM-116          | SSPL                   |
| SW-7             | 6.20          | 1,685                   | 16.5                | W-920901-JM-121          | SSPL                   |
| SW-8             | 7.10          | 1,497                   | 22.2                | W-920901-JM-122          | SSPL                   |
| SW-9             | 7.10          | 1,366                   | 19.7                | W-920901-JM-123          | SSPL                   |
| SW-10            | 7.30          | 1,382                   | 19.0                | W-920901-JM-125          | SSPL                   |
| SW-11            | 7.00          | 1,489                   | 19.8                | W-920901-JM-124          | SSPL                   |
| SW-12            | 6.80          | 1,160                   | 19.4                | W-920902-JM-133          | SSPL                   |
| SW-13            | 6.60          | 1,252                   | 18.6                | W-920902-JM-132          | SSPL                   |
| SW-14            | 6.40          | 1,151                   | 20.9                | W-920901-JM-126          | SSPL                   |
| SW-15            | 5. <i>7</i> 0 | 1,375                   | 19.5                | W-920902-JM-136          | SSPL                   |
| SW-16            | 5.00          | 3,980                   | <b>25</b> .7        | W-920902-JM-135          | SSPL                   |
| SW-17            | 5.10          | 2,000                   | 20.7                | W-920901-JM-127/128 DUP/ | SSPL & Hex             |
|                  |               |                         |                     | 129 MS/130 MSD/131RB     |                        |
| SW-18            | 5.80          | 364                     | 23.0                | W-920902-JM-134          | SSPL                   |
| SW-19            | -             |                         | _                   | DRY                      | ****                   |
| SW-20            |               |                         | -                   | DRY                      | **                     |
| SW-21            | -             | -                       |                     | DRY                      |                        |
| SW-22            | _             |                         |                     | DRY                      |                        |

## Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

Hex analysis parameter is hexavalent chromium.

Duplicate (DUP).

Matrix Spike (MS).

## SECOND ROUND SURFACE WATER SAMPLING SUMMARY WILMINGTON FACILITY

Second Round Surface Water (November 30, 1992 - January 7, 1993) (1)

| Location<br>I.D. | pН          | Conductivity<br>(µhmos) | Temperature<br>(°C) | Sample Identification    | Analysis<br>Parameters |
|------------------|-------------|-------------------------|---------------------|--------------------------|------------------------|
| SW-1             | 6.7         | 400                     | 9.3                 | W-921130-MJ-004          | SSPL                   |
| SW-2             | 6.4         | 400                     | 9.0                 | W-921130-MJ-003          | SSPL                   |
| SW-3             | 6.5         | 400                     | 9.2                 | W-921130-MJ-005          | SSPL                   |
| SW-4             | 6.3         | 400                     | 9.1                 | W-921130-MJ-002          | SSPL                   |
| SW-5             | 6.0         | 400                     | 9.3                 | W-921130-MJ-001          | SSPL                   |
| SW-6             | 7.1         | 1,600                   | 7.5                 | W-921201-MJ-017/018 DUP/ |                        |
|                  |             |                         |                     | 019 MS/020 MSD           | SSPL & Hex             |
| SW-7             | 6 <b>.3</b> | 1,200                   | 5.8                 | W-921201-MJ-009          | SSPL                   |
| SW-8             | <i>7</i> .1 | 1,500                   | 6.0                 | W-921201-MJ-014          | SSPL                   |
| SW-9             | 6.5         | 1,600                   | 8.2                 | W-921201-MJ-012          | SSPL                   |
| SW-10            | 6.7         | 1 <i>,</i> 700          | 8.6                 | W-921201-MJ-010          | SSPL                   |
| SW-11            | 6.7         | 1 <i>,7</i> 00          | 9.1                 | W-921201-MJ-011          | SSPL                   |
| SW-12            | 7.0         | 1,600                   | 12.3                | W-921201-MJ-016          | SSPL                   |
| SW-13            | 7.6         | 1,000                   | 9.5                 | W-921201-MJ-013          | SSPL                   |
| SW-14            | 6.5         | 1,800                   | 10.4                | W-921201-MJ-015          | SSPL                   |
| SW-15            | 6.1         | 1,500                   | 10.3                | W-921202-MJ-028          | SSPL                   |
| SW-16            | 5.2         | 4,200                   | 9.1                 | W-921202-MJ-027          | SSPL & Hex             |
| SW-17            | 6.0         | 600                     | 2.8                 | W-921202-MJ-021/022 DUP/ |                        |
|                  |             |                         |                     | 023 MS/024 MSD           | SSPL & Hex             |
| SW-18            | 5.5         | 300                     | 6.0                 | W-921202-MJ-025          | SSPL                   |
| SW-19            | 6.5         | NR                      | 7.0                 | W-921203-MJ-029          | SSPL                   |
| SW-20            | 4.7         | 400                     | 6.8                 | W-921201-MJ-008          | SSPL                   |
| SW-21            | 4.8         | 400                     | 5.6                 | W-921201-MJ-007          | SSPL                   |
| SW-22            | 5.1         | 300                     | 6.0                 | W-921201-MJ-006          | SSPL                   |
| SW-23            | 6.7         | 1,000                   | 5.3                 | W-921202-MJ-026          | SSPL & Hex             |
| SW-24            | NR          | NR                      | NR                  | W-930107-JM-135          | SSPL                   |
| SW-25            | <b>7.</b> 0 | 800                     | 3.0                 | W-930325-JM-01           | SSPL                   |
| SW-26            | <b>7.</b> 0 | 850                     | 4.0                 | W-930325-JM-02           | SSPL                   |
| SW-27            | 6.8         | 600                     | 4.0                 | W-930325-JM-03           | SSPL                   |
| SW-28            | 7.2         | 500                     | 3.0                 | W-930325-JM-04           | SSPL                   |
| SW-29            | 6.1         | 400                     | 12.0                | W-930420-MJ-005          | SSPL                   |
| SW-30            | 6.1         | 400                     | 12.0                | W-930420-MJ-006          | SSPL                   |

## Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate. Hex analysis parameter is hexavalent chromium.

Duplicate (DUP).

Matrix Spike (MS).

<sup>(1)</sup> Sampling conducted at locations after January 7, 1993 have been included as part of the Second Round Surface Water Sampling Event.

# FIRST ROUND SEDIMENT SAMPLING SUMMARY WILMINGTON FACILITY

## First Round Sediment Sampling (August 31 - September 2, 1992)

| Location<br>I.D. | Sample Identification      | Analysis<br>Parameters |
|------------------|----------------------------|------------------------|
| SW-1             | SED-920831-MJ-006          | SSPL                   |
| SW-2             | SED-920831-MJ-005          | SSPL                   |
| SW-3             | SED-920831-MJ-004          | SSPL                   |
| SW-4             | SED-920831-MJ-003          | SSPL                   |
| SW-5             | SED-920831-MJ-001          | SSPL                   |
| SW-6             | SED-920831-MJ-002          | SSPL                   |
| SW-7             | SED-920901-MJ-007          | SSPL                   |
| SW-8             | SED-920901-MJ-012          | SSPL                   |
| SW-9             | SED-920901-MJ-011          | SSPL                   |
| SW-10            | SED-920901-MJ-014          | SSPL                   |
| SW-11            | SED-920901-MJ-013          | SSPL                   |
| SW-12            | SED-920902-MJ-021          | SSPL                   |
| SW-13            | SED-920902-MJ-020          | SSPL                   |
| SW-14            | SED-920901-MJ-015          | SSPL                   |
| SW-15            | SED-920902-MJ-025          | SSPL                   |
| SW-16            | SED-920902-MJ-024          | SSPL                   |
| SW-17            | SED-920901-MJ-016/017 DUP/ | SSPL & Hex             |
|                  | 018 MS/019 MSD             |                        |
| SW-18            | SED-920902-MJ-023          | SSPL                   |
| SW-19            | SED-920902-MJ-022          | SSPL                   |
| SW-20            | SED-920901-MJ-008          | SSPL                   |
| SW-21            | SED-920901-MJ-009          | SSPL                   |
| SW-22            | SED-920901-MJ-010          | SSPL                   |

## Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

Hex analysis parameter is hexavalent chromium.

Duplicate (DUP).

Matrix Spike (MS).

## SECOND ROUND SEDIMENT SAMPLING SUMMARY WILMINGTON FACILITY

Second Round Sediment Sampling (November 30, 1992 - January 7, 1993)

| Location<br>I.D. | Sample Identification      | Analysis<br>Parameters |
|------------------|----------------------------|------------------------|
| SW-1             | SED-921130-MJ-004          | SSPL                   |
| SW-2             | SED-921130-MJ-003          | SSPL                   |
| SW-3             | SED-921130-MJ-005          | SSPL                   |
| SW-4             | SED-921130-MJ-002          | SSPL                   |
| SW-5             | SED-921130-MJ-001          | SSPL                   |
| SW-6             | SED-921201-MJ-017/018 DUP/ |                        |
|                  | 019 MS/020 MSD             | SSPL & Hex             |
| SW-7             | SED-921201-MJ-009          | SSPL                   |
| SW-8             | SED-921201-MJ-014          | SSPL & Hex             |
| SW-9             | SED-921201-MJ-012          | SSPL                   |
| SW-10            | SED-921201-MJ-010          | SSPL                   |
| SW-11            | SED-921201-MJ-011          | SSPL                   |
| SW-12            | SED-921201-MJ-016          | SSPL                   |
| SW-13            | SED-921201-MJ-013          | SSPL & Hex             |
| SW-14            | SED-921201-MJ-015          | SSPL                   |
| SW-15            | SED-921203-MJ-028          | SSPL                   |
| SW-16            | SED-921202-MJ-027          | SSPL & Hex             |
| SW-17            | SED-921202-MJ-021/022 DUP/ |                        |
|                  | 023 MS/024 MSD             | SSPL & Hex             |
| SW-18            | SED-921202-MJ-025          | SSPL                   |
| SW-19            | SED-921203-MJ-029          | SSPL                   |
| SW-20            | SED-921201-MJ-008          | SSPL                   |
| SW-21            | SED-921201-MJ-007          | SSPL                   |
| SW-22            | SED-921201-MJ-006          | SSPL                   |
| SW-23            | SED-921202-MJ-026          | SSPL & Hex             |
| SW-24            | SED-930107-MJ-001          | SSPL                   |
| SW-25            | S-930325-JM-01             | SSPL                   |
| SW-26            | S-930325-JM-02             | SSPL                   |
| SW-27            | S-930325-JM-03             | SSPL                   |
| SW-29            | SED-930420-MJ-001          | SSPL                   |
| SW-30            | SED-930420-MJ-001          | SSPL                   |

## Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

Hex analysis parameter is hexavalent chromium.

Duplicate (DUP).

Matrix Spike (MS).

<sup>(1)</sup> Sampling conducted at locations after January 7, 1993 have been included as part of the Second Round Sediment Sampling Event.

## SUBSURFACE SOIL SAMPLING SUMMARY WILMINGTON FACILITY

| BH01 6-8 06/05/91 BH02 6-8 06/05/91 BH03 6-8 06/05/91 BH04 6-8 06/06/91 BH05 6-8 06/06/91 BH06 4-6 06/06/91 BH07 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 10-12 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91 BH17 8-10 06/10/91 | Borehole<br>Location ID | Depth<br>(ft bgs) | Sample<br>Date<br>(mm/dd/yy) |
|---|-------------------------|-------------------|------------------------------|
| BH02 6-8 06/05/91 BH03 6-8 06/05/91 BH04 6-8 06/06/91 BH05 6-8 06/06/91 BH06 4-6 06/06/91 BH07 4-6 06/06/91 BH08 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 10-12 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91                    | BH01                    | 6-8               | 06/05/91                     |
| BH04 6-8 06/06/91 BH05 6-8 06/06/91 BH06 4-6 06/06/91 BH07 4-6 06/06/91 BH08 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 10-12 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91  | BH02                    |                   |                              |
| BH05 6-8 06/06/91 BH06 4-6 06/06/91 BH07 4-6 06/06/91 BH08 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 10-12 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91  | BH03                    | 6-8               |                              |
| BH06 4-6 06/06/91 BH07 4-6 06/06/91 BH08 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 10-12 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91  | BH04                    | 6-8               | 06/06/91                     |
| BH07 4-6 06/06/91 BH08 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 10-12 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91   | BH05                    | 6-8               | 06/06/91                     |
| BH08 4-6 06/06/91 BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 4-6 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91  | B <b>H</b> 06           | 4-6               | 06/06/91                     |
| BH09 4-6 06/06/91 BH10 4-6 06/06/91 BH11 4-6 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91  | BH07                    | 4-6               | 06/06/91                     |
| BH10 4-6 06/06/91 BH11 4-6 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91  | BH08                    | 4-6               | 06/06/91                     |
| BH11 4-6 06/07/91 BH11 10-12 06/07/91 BH12 4-6 06/10/91 BH13 8-10 06/10/91 BH14 4-6 06/10/91 BH15 8-10 06/10/91 BH16 4-6 06/10/91 BH17 8-10 06/10/91  | BH09                    |                   | 06/06/91                     |
| BH11 10-12 06/07/91<br>BH12 4-6 06/10/91<br>BH13 8-10 06/10/91<br>BH14 4-6 06/10/91<br>BH15 8-10 06/10/91<br>BH16 4-6 06/10/91<br>BH17 8-10 06/10/91  | BH10                    |                   | 06/06/91                     |
| BH12 4-6 06/10/91<br>BH13 8-10 06/10/91<br>BH14 4-6 06/10/91<br>BH15 8-10 06/10/91<br>BH16 4-6 06/10/91<br>BH17 8-10 06/10/91   |                         |                   | 06/07/91                     |
| BH13 8-10 06/10/91<br>BH14 4-6 06/10/91<br>BH15 8-10 06/10/91<br>BH16 4-6 06/10/91<br>BH17 8-10 06/10/91  |                         | 10-12             | 06/07/91                     |
| BH14 4-6 06/10/91<br>BH15 8-10 06/10/91<br>BH16 4-6 06/10/91<br>BH17 8-10 06/10/91  |                         |                   | 06/10/91                     |
| BH15       8-10       06/10/91         BH16       4-6       06/10/91         BH17       8-10       06/10/91   |                         |                   | ·                            |
| BH16 4-6 06/10/91<br>BH17 8-10 06/10/91   |                         |                   |                              |
| BH17 8-10 06/10/91  |                         |                   |                              |
| •   |                         |                   |                              |
| RHIX 14 07./10./01  |                         |                   | •                            |
| ···   | BH18                    | 4-6               | 06/10/91                     |
| BH19 5-7 06/11/91   |                         |                   |                              |
| BH20 10-12 06/10/91   |                         |                   |                              |
| BH21 8-10 06/10/91  |                         |                   |                              |
| BH22 8-10 06/10/91  |                         |                   |                              |
| BH23 4-6 06/10/91   |                         |                   |                              |
| BH24 4-6 06/10/91<br>BH25 4-6 06/10/91  |                         |                   |                              |
|   |                         |                   |                              |
|   |                         |                   |                              |
|   |                         |                   |                              |
|   |                         |                   |                              |
| BH29 4-6 06/11/91<br>BH30 8-10 06/11/91   |                         |                   |                              |
| BH31 3-5 06/11/91   |                         |                   |                              |
| BH32 4-6 06/11/91   |                         |                   | · ·                          |
|   |                         |                   |                              |
| BH32 4-6 06/11/91<br>BH33 6-8 06/11/91  |                         |                   |                              |
| BH34 6-8 06/11/91   |                         |                   |                              |
| BH35 6-8 06/11/91   |                         |                   |                              |
| BH36 4-6 02/06/91   |                         |                   | • •                          |
| BH37 4-6 02/06/91   |                         |                   |                              |
| BH38 3-5 02/06/91   |                         |                   |                              |
| BH39 4-6 02/06/91   |                         |                   |                              |
| BH40 4-6 02/06/91   |                         |                   |                              |
| BH41 10 - 12 11/02/92   |                         |                   |                              |

Notes:

ft bgs - feet below ground surface

# SURFACE SOIL SAMPLING SUMMARY WILMINGTON FACILITY

| Surface Soil<br>Location | Sample<br>Date<br>(mm/dd/yy) | Analysis     |
|--------------------------|------------------------------|--------------|
| Grid Locations           |                              |              |
| AREA 01                  |                              |              |
| SE Corner                | 07/08/91                     | SSPL         |
| SW Corner                | 07/08/91                     |              |
| NW Corner                | 07/08/91                     |              |
| NE Corner                | 07/08/91                     |              |
| AREA 02                  |                              |              |
| SE Corner                | 07/09/91                     | <i>S</i> SPL |
| SW Corner                | 07/09/91                     |              |
| NW Corner                | 07/09/91                     |              |
| NE Corner                | 07/09/91                     |              |
| AREA 03                  |                              |              |
| SE Corner                | 07/09/91                     | SSPL         |
| SW Corner                | 07/09/91                     |              |
| NW Corner                | 07/09/91                     |              |
| NE Corner                | 07/09/91                     |              |
| AREA 04                  |                              |              |
| SE Corner                | 07/09/91                     | SSPL         |
| SW Corner                | 07/09/91                     |              |
| NW Corner                | 07/09/91                     |              |
| NE Corner                | 07/09/91                     |              |
| AREA 05                  |                              |              |
| SW Corner                | 07/09/91                     | SSPL         |
| NW Corner                | 07/09/91                     |              |
| NE Corner                | 07/09/91                     |              |
| SE Corner                | 07/09/91                     |              |
| AREA 06                  |                              |              |
| SW Corner                | 07/09/91                     | SSPL         |
| NW Corner                | 07/09/91                     |              |
| NE Corner                | 07/09/91                     |              |
| SE Corner                | 07/09/91                     |              |
| AREA 07                  |                              |              |
| SE Corner                | 07/09/91                     | SSPL         |
| SW Corner                | 07/09/91                     |              |
| NW Corner                | 07/09/91                     |              |
| NE Corner                | 07/09/91                     |              |

## SURFACE SOIL SAMPLING SUMMARY WILMINGTON FACILITY

| Surface Soil<br>Location | Sample<br>Date<br>(mm/dd/yy) | Analysis                 |
|--------------------------|------------------------------|--------------------------|
| AREA 08                  |                              |                          |
| SE Corner                | 07/09/91                     | SSPL                     |
| SW Corner                | 07/09/91                     |                          |
| NW Corner                | 07/09/91                     |                          |
| NE Corner                | 07/09/91                     |                          |
| AREA 09                  |                              |                          |
| Southernmost             | 07/09/91                     | SSPL                     |
| 2nd Southernmost         | 07/09/91                     |                          |
| 2nd Northernmost         | 07/09/91                     |                          |
| Northernmost             | 07/09/91                     |                          |
| AREA 10                  |                              |                          |
| SW Corner                | 07/09/91                     | SSPL                     |
| NW Corner                | 07/09/91                     |                          |
| NE Corner                | 07/09/91                     |                          |
| SE Corner                | 07/09/91                     |                          |
| Hand Auger Locations     | •                            |                          |
| SWMU No. 25              | 05/07/93                     | SSPL                     |
| SWMU No.27               | 07/30/91 - 04/22/93          | SSPL and Hex             |
| SWMU No. 30              | 07/30/91                     | SSPL                     |
| SWMU No. 33              |                              | SSPL                     |
| Background Locations     |                              |                          |
| BH-41                    | 11/02/92                     | TCL PAHs, TAL parameters |

## Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

Hex analysis parameter is hexavalent chromium.

TCL PAHs is TCL polynuclear aromatic hydrocarbons.

**TABLE 4.18** 

## SUMMARY OF DETECTED PARAMETERS TOWN WELL SAMPLES WILMINGTON FACILITY

|                                   | Butters<br>Row | Butters<br>Row | Town<br>Park | Chestnut<br>Street   | Chestnut<br>Street | After<br>Treatment |
|-----------------------------------|----------------|----------------|--------------|----------------------|--------------------|--------------------|
| Parameter/Well                    | #1             | #1A            |              | #1                   | #1 <i>A</i>        |                    |
| Volatile Organics (ug/L)          |                |                |              |                      |                    |                    |
| Vinyl chloride                    | 0.24J          | 0.37J          | ND(0.40)     | ND(0.40) / ND(0.40)  | ND(0.40)           | ND(0.40)           |
| Methylene chloride                | 1.1B           | 1.7B           | 1.7B         | 1.1B / 1.1B          | 2.7B               | 1.7B               |
| trans-1,2-Dichloroethene          | 0.28           | ND(0.17)       | ND(0.17)     | ND(0.17) / ND(0.17)  | ND(0.17)           | ND(0.17)           |
| 1,1-Dichloroethane                | 0.20           | 0.16J          | ND(0.18)     | ND(0.18) / ND(0.18)  | ND(0.18)           | ND(0.18)           |
| Cis-1,2-Dichloroethene            | 33             | 12             | 2            | 5.2 / 5.2            | 0.21               | 3.2                |
| Chloroform                        | ND(0.26)       | ND(0.26)       | ND(0.26)     | ND(0.26) / ND(0.26)  | 2.6                | 0.95B              |
| 1,2-Dichloroethane                | 0.10}          | ND(0.21)       | ND(0.21)     | ND(0.21) / ND(0.21)  | ND(0.21)           | ND(0.21)           |
| Benzene                           | 0.11J          | ND(0.39)       | ND(0.39)     | ND(0.39) / ND(0.39)  | ND(0.39)           | ND(0.39)           |
| Trichloroethene                   | 1.5            | 0.22           | 2 <i>.7</i>  | 5.0 / 4.8            | 0.51               | 0.22               |
| Bromodichloromethane              | ND(0.20)       | ND(0.20)       | ND(0.20)     | ND(0.20) / ND(0.20)  | ND(0.20)           | 0.61               |
| Dibromochloromethane              | ND(0.16)       | ND(0.16)       | ND(0.16)     | ND(0.16) / ND(0.16)  | ND(0.16)           | 0.22               |
| Tetrachloroethene                 | ND(0.20)       | ND(0.20)       | 0.16J        | ND(0.20) / ND(0.20)  | ND(0.20)           | ND(0.20)           |
| Chlorobenzene                     | 0.24           | ND(0.20)       | ND(0.20)     | ND(0.20) / ND(0.20)  | ND(0.20)           | ND(0.20)           |
| Napthalene                        | 1.1B           | 0.46B          | 0.26JB       | 0.19JB / 0.10JB      | 1.2                | 0.15JB             |
| Priority Pollutant Semivolatile O | rganics (µg/L) |                |              |                      |                    |                    |
| Phenol                            | ND(10)         | ND(10)         | ND(10)       | ND(10) / ND(10)      | ND(10)             | 1J                 |
| 1,3-Dichlorobenzene               | ND(10)         | ND(10)         | ND(10)       | ND(10) / 1]          | 1]                 | ND(10)             |
| Diethylphthalate                  | 5J             | ND(10)         | ND(10)       | ND(10) / ND(10)      | ND(10)             | ND(10)             |
| bis(2-Ethylhexyl)phthalate        | ND(10)         | ND(10)         | ND(10)       | 12B / ND(10)         | 3J                 | ND(10)             |
| Metals (mg/L)                     |                |                |              | •                    |                    |                    |
| Aluminum, Total                   | ND(0.10)       | ND(0.10)       | 0.14         | ND(0.10) / ND(0.10)  | ND(0.10)           | ND(0.10)           |
| Arsenic, Total                    | 0.010          | ND(0.005)      | ND(0.005)    | ND(0.005) / ND(0.005 | ND(0.005)          | ND(0.005)          |
| Barium, Total                     | 0. <b>02</b> 6 | 0.023          | 0.026        | 0.020 / 0.020        | 0.013              | 0.014              |
| Copper, Total                     | 0.027          | ND(0.025)      | ND(0.025)    | ND(0.025) / ND(0.025 | ND(0.025)          | ND(0.025)          |
| Iron, Total                       | 3.9            | 7.9            | 4.0          | 1.9 / 1.9            | 0.25               | ND(0.025)          |
| Lead, Total                       | ND(0.005)      | ND(0.005)      | ND(0.005)    | 0.006 / ND(0.005     | ND(0.005)          | ND(0.005)          |
| Manganese, Total                  | 0.73           | 0.27           | 0.48         | 0.76 / 0.75          | 0.020              | 0.015              |
| Sodium, Total                     | 50             | 37             | 40           | 47 / 47              | 25                 | 36                 |
| Zinc, Total                       | 0.028          | ND(0.025)      | ND(0.025)    | 0.035 / ND(0.025     | ) ND(0.025)        | ND(0.025)          |
| Other Compounds (mg/L)            |                |                |              |                      |                    |                    |
| Chloride                          | 74             | 64             | 72           | 71 / 71              | 41                 | 59                 |
| Nitrate as N                      | ND(0.050)      | 0.35           | 0.53         | ND(0.050) / 0.18     | 0.58               | ND(0.050)          |
| Nitrite as N                      | 0.050          | ND(0.050)      | ND(0.050)    | ND(0.050) / ND(0.050 |                    | ND(0.050)          |
| Nitrogen, Total Kjeldahl as N     | 2.1            | 0.45           | 0.44         | 0.72 / 0.56          | 0.60               | 0.53               |
| Nitrogen-Ammonia as N             | 2.1            | 0.35           | 0.34         | 0.33 / 0.40          | ND(0.10)           | ND(0.10)           |
| Sulfate                           | 54             | 40             | 27           | 22 / 31              | ì9                 | \$ <b>7</b>        |
|                                   |                |                |              | •                    |                    |                    |

## Notes:

 $<sup>\</sup>mbox{\it J}$  - indicates an estimated value - detected at concentrations greater than MDL but less than  $\mbox{\it PQL}$ 

B - indicates detection in method blank

<sup>/ -</sup> indicates results of duplicate analysis

TABLE 5.1

BEDROCK JOINT AND FRACTURE ORIENTATION MEASUREMENTS
WILMINGTON FACILITY

| Fracture/Joint           |             |               |
|--------------------------|-------------|---------------|
| Strike (Compass Bearing) | Dip/Angle   | Dip Direction |
| 48°                      | 45°         | N             |
| 55°                      | 70°         | N             |
| 5°                       | 40°         | N             |
| 30°                      | 74°         | N             |
| 39°                      | 78°         | N             |
| 40°                      | 88°         | N             |
| 32°                      | 70°         | N             |
| 50°                      | <b>45</b> ° | N             |
| 50°                      | 65°         | N             |
| 290°                     | 74°         | S             |
| 45°                      | 45°         | N             |
| 35°                      | <b>7</b> 0° | S             |

TABLE 6.1

NATURAL BACKGROUND LEVELS OF METALS IN SOILS FOR THE EASTERN UNITED STATES

WILMINGTON FACILITY

| Element        | Range in PPM         | Reference | Notes |
|----------------|----------------------|-----------|-------|
| Aluminum - Al  | 10,000 - 300,000     | 1,2,5     |       |
| Antimony - Sb  | 1.25 - 10            | 3,4,5     |       |
| Arsenic - As   | 0.1 - 73             | 1,2,4,5   |       |
| Barium - Ba    | 10 - 3,000           | 1,2,4,5   |       |
| Beryllium - Be | 0.1 - 40             | 1,2,4,5   |       |
| Cadmium - Cd   | 0.01 - 0.70          | 1,2,4     | A     |
| Chromium - Cr  | 1 - 1000             | 1,2,4,5   |       |
| Copper - Cu    | <1 - 700             | 1,2,4,5   | В     |
| Iron - Fe      | 7000 - 550,000       | 1         |       |
| Lead - Pb      | 2 - 300              | 1,2,4,5   |       |
| Lithium - Li   | 5 - 200              | 1,2,4     |       |
| Magnesium - Mg | 600 - 6,000          | 1,2       |       |
| Manganese - Mn | 12 - 7,000           | 1,2,4,5   |       |
| Mercury - Hg   | 0.01 - 3.4           | 1,2,4,5   | C     |
| Nickel - Ni    | 5 - 700              | 1,2,4,5   |       |
| Potassium - K  | 50 - 3 <b>7,</b> 000 | 1,5       |       |
| Selenium - Se  | 0.1 - 3.9            | 1,2,4,5   |       |
| Silver - Ag    | 0.01 - 5             | 1,2,4     |       |
| Thallium - Tl  | no ranges reported   |           |       |
| Vanadium - V   | 20 - 500             | 1,2,4     |       |
| Zinc - Zn      | 5 - 2,900            | 1,2,4,5   |       |

#### Notes:

- A Cadmium has been reported through many studies in the 1 to 10 ppm range consistantly.

  NUS QNSH reported 0.27 to 33 ppm with a mean of 6.3; background in New Jersey is reported at 1 to 4 ppm; up to 3 ppm in Somerville (Boynton Yards 21E). It should also be noted that usually less than 10% of the samples have detectable concentrations of Cd.
- B Although given a range in the Eastern US up to 700 ppm, copper by most researchers does not usually exceed 200 ppm, with most reporting 100 ppm or less. For a site in Woburn (Whitney Barrel), with 23 soil samples, copper ranged from 3 to 39 ppm.
- Mercury is another element that is given a higher natural range (3.4 ppm) for the Eastern US by one researcher (ref. #5) than the others (0.3 ppm). Soils analyzed from QNSY, Boynton Yards, and Whitney Barrel all have reported concentrations of less than 1.0 ppm.

#### References:

- Dragun, James 1988. <u>The Soil Chemistry of Hazardous Materials</u>. Hazardous Materials Control Research Institute, Silver Spring, MD.
- 2. Lindsay, W.L. 1979. Chemical Equilibria in Soils. John Wiley and Sons, New York.
- 3. Bown, H.J. 1966. Trace Elements in Biochemistry. Academic Press, New York.
- Brooks, R.R. 1977 Pollution through Trace Elements. In <u>Environmental Chemistry</u>, Brockis, J. O'M., ed. Plenum Press, New York.
- Shacklette, H.T. and Boerngen, J.C. 1984. Element Concentrations in Soils and Other Surface Materials in Conterminous United States. <u>U.S. Geological Survey Professional Paper 1270</u>. U.S. Government Printing Office, Washington.

TABLE 6.2

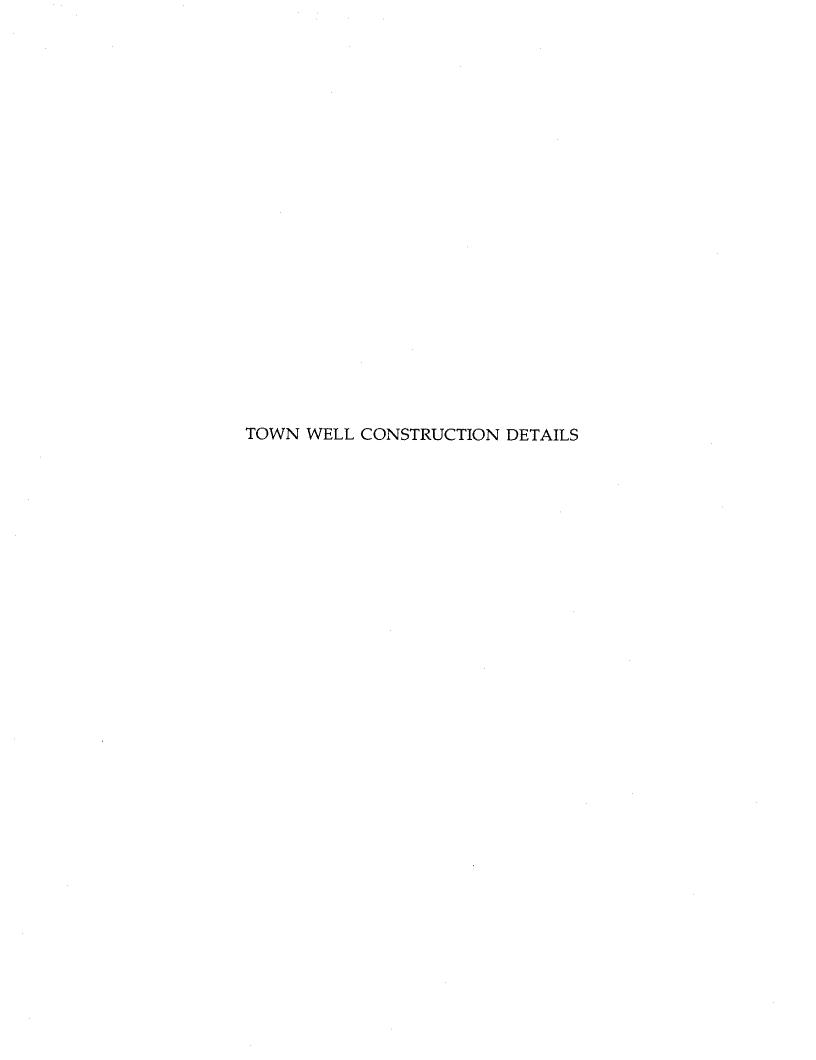
SPECIFIC GRAVITY ANALYSIS SUMMARY
WILMINGTON FACILITY

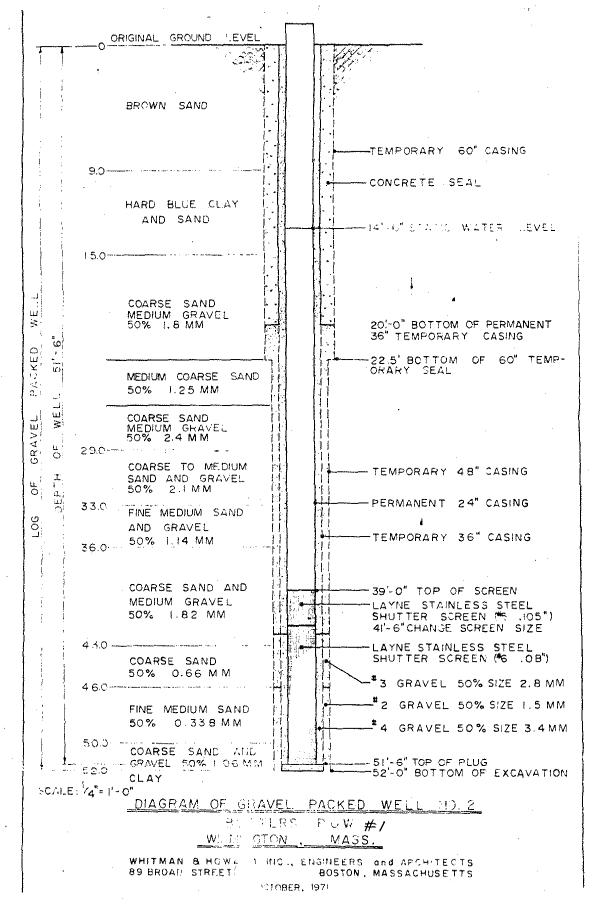
| Well               | Specific Gravity (g/mL) |            |  |
|--------------------|-------------------------|------------|--|
| I.D.               | Round 1                 | Round 2    |  |
| Shallow Monitoring | Wells                   |            |  |
| GW-27S             | 1.005                   | 1.022      |  |
| GW-43S             | 1.005                   | 1.032      |  |
| GW-44S             |                         | 1.022      |  |
| GW-45S             | 1.005                   | alerate    |  |
| GW-50S             | 1.016                   | 1.004      |  |
| GW-58S             | 0.991                   | 1.005      |  |
| GW-59S             | 1.010                   | 1.003      |  |
| GW-62M             | 1.000                   |            |  |
| GW-66S             | 1.023                   |            |  |
| IW-4               | 0.986                   | ·          |  |
|                    | Average 1.005           | 1.015      |  |
| Deep Monitoring We | ells                    |            |  |
| GW-27D             | 1.005                   | 1.052      |  |
| GW-36              | 1.091                   |            |  |
| GW-37              | 1.089                   | aqua aqua  |  |
| GW-40D             | 0.989/1.008             | 1.023      |  |
| GW-42D             | 1.116/1.10              | 1.118      |  |
| GW-43D             | 1.035/1.015             | 1.021      |  |
| GW-44D             | 1.051                   | 1.083      |  |
| GW-45D             | 1.061                   | 1.051      |  |
| GW-50D             | 1.015/1.002             | Wester     |  |
| GW-58D             | 1.002                   | 1.017      |  |
| GW-59D             | 1.068/1.048             | 1.050      |  |
| GW-62BR            | 1.004                   | 1.029      |  |
| GW-66D             | 1.004                   | vito vite- |  |
| GW-70D             | 1.044                   |            |  |
|                    | Average 1.039           | 1.049      |  |

# APPENDIX A

## APPENDIX A

TOWN WELL/ALTON WELL CONSTRUCTION DETAILS





PUMP : SINGLE STAGE 500 GPM @ 104' TDH MOTOR: 20 HP; 6"; 460 VOLT; 3 PHASE SPECIFIC CAPACITY: 50 GPM/FT AUGUST, 1991 (AT END OF 48 HR TEST) PITLESS ADAPTER : MODEL NO. MB HD WITH FLOW METER 2'-0" <del><\y</del>/X\Y/X\Y// 3'-0" **BROWN COARSE SAND AND GRAVEL** 8. DISCHARGE STATIC WATER LEVEL (8/14/91) 54" TEMPORARY CASING BROWN COARSE GRAVEL CONCRETE SEAL 48' TEMPORARY CASING BROWN COARSE BAND AND MEDERM GRAVEL WELL -FINE SAND PACKED .22 BROWN COARSE SAND AND SOME GRAVEL 55 -0" GRAVEL 28 BROWN COARSE SAND AND SOME FINE SAND GRAVEL ö 507 BROWN MEDIUM SAND 36" TEMPORARY CASING 24' PERMANENT CASING BROWN MEDIUM SAND TO COARSE SAND 44' TOP OF SCREEN BROWN COARSE SAND AND TRACE OF GRAVEL 46 BROWN CDARSE SAND AND SOME GRAVEL -BO SLOT STAINLESS STEEL SCREEN BOTTOM OF MOTOR 54' BROWN COARSE SAND 56' BROWN FINE SAND **GRAVEL PACKED WELL 1A CHESTNUT STREET** WILMINGTON, MA AUGUST, 1991

Dufresne-Henry, Inc. Westford, Ma SCALE : HORIZ. 1/2" = 1'-0" VERT, 3/16" = 1'-0"

## WILMINGTON

## Chestnut Street

## Log of 8" Well No. 2

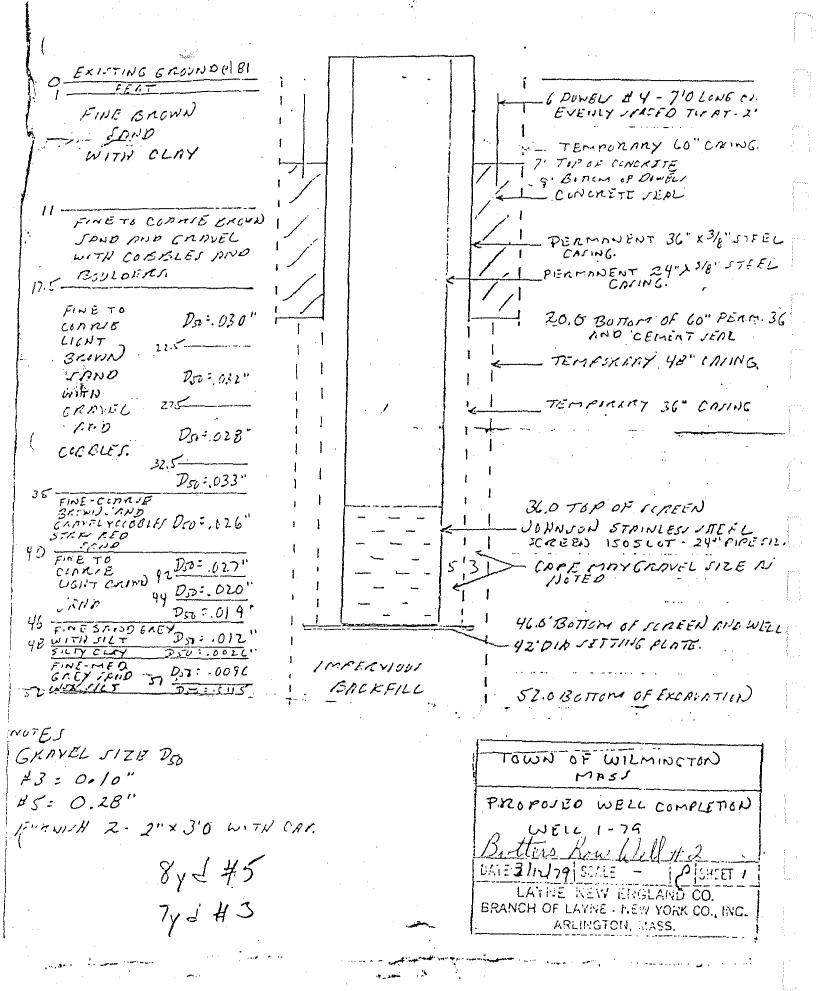
0 - 10' Brown coarse gravel

10' - 22' Brown sand

22' - 46' Brown coarse gravel Stopped at 46'-0"

Set 80 slot screen at 46'-0"

Pumped 500 g.p.m. with 5' of d.d in 8" well.



# Chestnot St. Well (Old Well)

Engineer's: Whitman 3 Howard

Distabled: 9/61 Well

Depth of Well: 55' Sravel Packed by Layre Pump

Casing: 24"

Stainless Steel Screen 15'

Pump: Layre Pump 3 stage with 8" column

Rated: 700 GPM

Depth to section 37'-11"

An line: 39'

Pump or replaced: 3/14/86 3 stage pump, the old

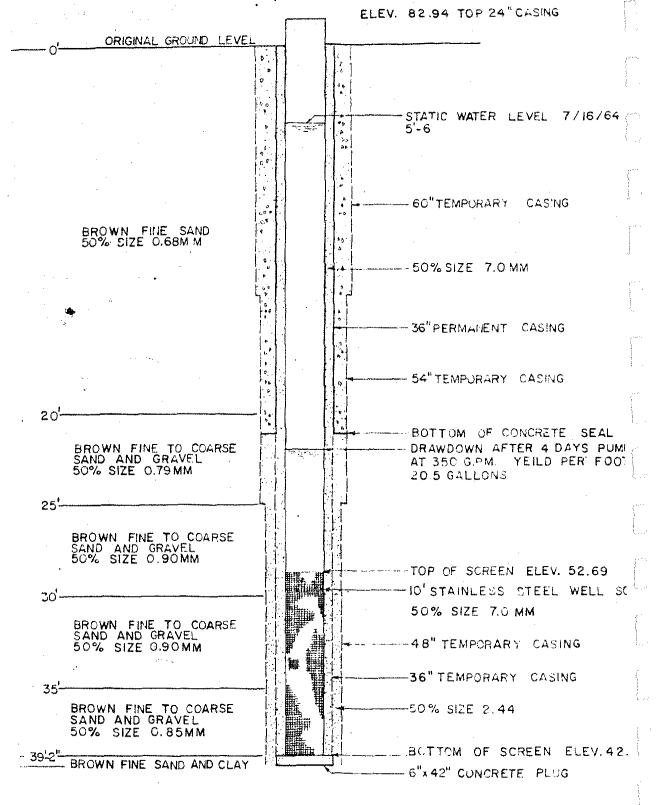
columns and shafts were reused, except for one new

5' column above the new 3 stage pump.

Motor H. P. 25 US MOTORS

COMPRESSOR - KELLOGG AMERICAN MODEL- 211TV

CCNIPAESSOR TANK- KARCARD INDUSTRIES, INC UR. 165 TEAR. 450' YEAR BUILT 1980



1/4"=1'-0"

## DIAGRAM OF GRAVEL PACKED WELL NO. 5

TOWN PARK

## WILMINGTON , MASS.

TWHITMAN & HOWARD INC., ENGINEERS and ARCHITECTS 89 BROAD STREET BOSTON, MASSACHUSETTS

JULY 1964

The six remaining municipal well sites consist of individual gravel-packed well Their completion dates, depths, and estimated specific capacity are shown in Tab 7.2. In 1981, a treatment plant was built at the Butters Row site. The discharge from Butters Row, Chestnut Street and Town Park are combined at the Butters Row Treatment Plant. This treatment plant and the one at the Barrows site are discussed more fully in Section 9.0. The Shawsheen and Aldridge Road wells are not currently connected to a water treatment facility and are not in regular use duprimarily to high iron and manganese concentrations in the ground water.

Table 7.2
WILMINGTON MUNICIPAL WELL DATA

| Well             | Screen<br>Depth(s) | Date<br>Installed | Specific<br>Capacity |
|------------------|--------------------|-------------------|----------------------|
| Browns Crossing  | 37'-72'            | 1927              | ND                   |
| Salem Street     | 29'-39'            | 1969              | 53.24                |
| Barrows          | 30'                | 195 <b>7</b>      | ND                   |
| Shawsheen Avenue | 25'-35'            | 1965              | 39.08                |
| Aldrich Road     | ND                 | 1966              | 19.78                |
| Chestnut Street  | 31'-36' 51-44      | 1960              | 116.6                |
| (Town Park)      | 40'                | 1965              | 22.5                 |
| Butlers Row #1   | 42'-52'            | 1971              | 46.3                 |
| Butlers Row #2   | 36'-46'            | 1979              | 51.09                |

ND = No Data

The combined yield of all Wilmington's municipal wells is approximately 1 billion gallons per year. The average yield and design yield for each municipal we site is shown in Table 7.3. The design yield represents the designed pumpil capacity at individual well sites and does not necessarily reflect the long term say ield of the aquifer.

Because of the favorable geologic conditions for ground water development in t Wilmington area, the municipal wells for the Towns of Reading and Nor Reading are located near the Wilmington Town line. These wells need to considered in any analysis of Wilmington ground water conditions as they drawater from the same aquifer system and the zones of contribution to these wells f largely within the Town of Wilmington. The Reading Wells include: The 100 Ac Wellfield near the main channel of the Ipswich River and two wells along Rev Brook. The North Reading Wells include Lakeside, Route 125, Railroad bed, Cents Street and Stickney Wells. The current pumping status and maximum design yiel for these wells are also listed in Table 7.3. The Reading and North Reading wells also shown as Figure 7.2.

# Table 7.3 MUNICIPAL WELL YIELDS

#### WILMINGTON

|                  | Maximum I | Design Yield | Average Pu | imping Rate |
|------------------|-----------|--------------|------------|-------------|
|                  | MGD       | GPM.         | MGD        | CRM :       |
| Brown's Crossing | 1.55      | 1076         | 0.9        | 600         |
| Salem Street     | 1         | 700          | 0.5        | 350         |
| Barrows          | 0.9       | 650          | (0.5)*     | (350)*      |
| Shawsheen Avenue | 0.7       | 500          | (0.6)*     | (383)*      |
| Aldrich Road     | 0.5       | 350          | (0.5)*     | (350)*      |
| Chestnut Street  | 1.4       | 950          | 0.5        | 350         |
| Town Park        | 0.5       | 350          | 0.2        | 180         |
| Butters Row #1   | 1.3       | 900          | 0.7        | 450         |
| Butters Row #2   | 1.4       | 950          | 0.9        | 650         |
| TOTAL            | 9.3       | 6426         | 3.7        | 2580        |

Information obtained from Paul Duggan, Wilmington Water & Sewer Department, 3/9/90.

## NORTH READING

|                | Maximum De    | Maximum Design Yield |     | Pumping Rate |
|----------------|---------------|----------------------|-----|--------------|
|                | MGD           | GPM                  | MGD | GPM .        |
| Route 125      | 0.2           | 131                  |     |              |
| Central Street | 0.3           | 250                  | 0.2 | 134          |
| Lakeside       | 0.6           | 583                  | 0.6 | 382          |
| Railroad Bed   | 0.5           | 312                  | 0.3 | 188          |
| Stickney       | Offline/VOC   |                      |     |              |
|                | contamination |                      | -   |              |
| TOTAL          | 1.6           | 1276                 | 1.1 | 704          |

Information obtained from Steve Cassaza, Town of North Reading Engineer, 3/9/90.

#### READING

|                    | Maximum De    | Maximum Design Yield |             | Pumping Rate                        |
|--------------------|---------------|----------------------|-------------|-------------------------------------|
|                    | MGD           | GM.                  | MCD         | CPM C                               |
| 100-Acre Wellfield |               |                      |             |                                     |
| 2                  | 0.9           | 650                  |             |                                     |
| 3                  | 0.4           | 250                  |             |                                     |
| 13                 | 1             | 700                  |             |                                     |
| 15                 | 1.1           | <i>75</i> 0          | 2.2         | 1509                                |
| 66-8               | 0.7           | 500                  |             | (Combined Yield                     |
| B-Line             | 1.1           | <i>7</i> 50          |             |                                     |
| Town forest        | 1.5           | 1000                 |             |                                     |
| 82-20              | Offline VOC   |                      |             |                                     |
|                    | Contamination |                      | <del></del> | <del></del>                         |
| Revay Brook        | 1             |                      |             |                                     |
| Ī                  | 0.9           | 600                  | <del></del> | Not in regular use<br>- high sodium |
| 2                  | not used      | <del></del>          |             | levels                              |
| TOTAL              | 7.6           | 5200                 | 2.2         | 1509                                |

12902

7.0

Information obtained from Peter Taffi, Reading Water Department, 3/0/90.

18.5

\*Not currently in use (see Section 7.3) ND = No Data

COMBINED TOTAL

MGD = Million Gallons per Day

GPM = Gallons per Minute

NA = Not Available

4793

Table 7.1
WILMINGTON WATER TABLE ELEVATIONS

| Well           | Well<br>Elevation                                | Water<br>Depth<br>11/16/89 | Water<br>Elevation<br>11/16/89                   | Water<br>Depth<br>1/18/90 | Water<br>Elevation<br>1/18/90 |
|----------------|--|----------------------------|--|---------------------------|-------------------------------|
| Aldrich Road   |  |                            |  |                           |                               |
| 1              | 105.43   | 4.20                       | 101.23   | 4.36                      | 101.07                        |
| 2              | 105.83   | 4.60                       | 101.23   | 4.84                      | 100.99                        |
| 3              | 107.41   | 6.20                       | 101.21   | 6.37                      | 101.03                        |
| Barrows        |  |                            |  |                           |                               |
| Wellfield      |  | <b>D</b> 40                | 77m m.c.   |                           | FF 50                         |
| 1              | 75.79  | 2.40                       | 73.39  | <u></u>                   | 75.79                         |
| Brown's        |  |                            |  |                           |                               |
| Crossing 2     | 76.91  | 8.00                       | 68.91  | 7.99                      | 68.92                         |
| Butter's Row   | 70.71  | 0.00                       | 00.91  | 7.33                      | 00.92                         |
| 1              | 87.81  | 12.60                      | 75. <b>2</b> 1                                   | 15.31                     | 72.50                         |
|                | 79.79  | 5.30                       | 74.49  | 8.26                      | 71.53                         |
| Chestnut St.   |  |                            | ,  |                           | 7                             |
| 1              | 84.81  | 3.65                       | 81.16  | 4.59                      | 80.22                         |
| IA )           | 81.51  | 3 <i>7</i> 5               | 77.76  | 4.70                      | 76.81                         |
| 2              | 81.18  | 3.25                       | 77.93  | 4.18                      | <i>7</i> 7.00                 |
| 3              | 81.26  | -                          | - , <b></b> .                                    | 4.16                      | 77.10                         |
| 4              | 82.16  |                            | •  | 5.63                      | 76.53                         |
| Salem St.      | <del>,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,</del> | ,                          | <del>,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,</del> |                           |                               |
| 1              | 76.13  | 7.40                       | 68.73  | 9.17                      | 66.96                         |
| 2              | 76.71  | 11.40                      | 65.13  | 13.17                     | 63.54                         |
| Shawsheen Ave. |  |                            |  |                           |                               |
| 1              | 99.13  | 4 <i>.</i> 70              | 94.43  | 5. <b>2</b> 9             | 93.84                         |
| 2              | 97.91  | 3.50                       | 94.41  | 3.91                      | 94.00                         |
| Town Park      | 81.33  | 4.90                       | 76.43  | 4.24                      | 77.09                         |
| Piezometers    |  | 4.20                       | 70.45  | 1/9/90                    | 1/9/90                        |
| PZ-1           | 75.78  |                            |  | 1.62                      | 74.16                         |
| PZ-2           | 78.53  |                            |  | 1.57                      | 76.96                         |
| PZ-3           | <b>79.3</b> 9                                    |                            |  | 1.40                      | 77.99                         |
| PZ-4           | 82.24  |                            |  | 1.41                      | 80.83                         |
| PZ-5           | 97.28  |                            |  | 3.41                      | 93.87                         |
| PZ-6           | 90.23  |                            |  | 1.85                      | 88.38                         |
| PZ-7           | 76.99  |                            |  | 2.93                      | 74.06                         |
| PZ-8           | 74.74  |                            |  | 0.75                      | <b>73.9</b> 9                 |
| PZ-9           | 98.42  |                            |  | 1 <i>.7</i> 5             | 96.67                         |
| PZ-10          | 107.47   |                            |  | 1.39                      | 106.08                        |
| PZ-11          | 99.29  |                            |  | 1.22                      | 98.07                         |
| PZ-12          | 84.31  |                            |  | 2.45                      | 81.86                         |
| PZ-13          | 84.08  |                            |  | 2.91                      | 81.17                         |
| PZ-14          | 111.27   |                            |  | 3.30                      | 107.97                        |
| PZ-15          | 81.55  |                            |  | 2.63                      | 78.92                         |

NOTE: Water levels measured in feet Wells and piezometers surveyed to NGVD SOURCE A Tub. Wells Brown's Crossing - 342 016

# THE COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING WATER SUPPLY ANALYSIS (mg/per liter)

Hue

Wilmington
COLLECTOR Vicina

- OFF CINE 4-1-86 SOURCE B " Barrow's - 342-02G --SOURCE C G.P Well, Chestnut St. - 342-03G SOURCE D " " Town Park Well - 342-04G-CIFFE 11 SOURCE E " " Shawsheen Ave. - 342-05G = WATER TREATMENT PLANT Butters Row -2 - 343-06G -SOURCE P " " λ C Ď F E 463 573462 464 SAMPLE NO. 465 466 447 DATE OF COLLECTION 4/1/86 4/1/86 DATE OF RECEIPT 0.2 1.4 3.0 3.0 5.1 2.5 TURBIDITY 0 SEDIMENT 0 0 0 0 COLOR 0 25 10 0.6 27 30 0 0 0 0 0 ODOR Ĺ, 6.0 6.3 6.1 6.0 6.0 G. 0 рн ALKALINITY-TOTAL (CaCO3) 20 38 28 26 23 23 56 78 HARDNESS (CaCQ3) 55 77 40 68 CALCIUM(Ca) 16. 24. 16. 24. 11. 20. 3.9 4.4 3.7 4.2 3.0 4.5 MAGNESIUM (Mg) 42. 27. SODIUM (Na) 50. 37. 18. 30. 2.0 2.0 1.6 2.0 1.5 2.2 POTASSIUM (K) .14 IRON (Fe) .29 .73 1,4 3.8 .30 .20 .35 .78 MANGANESE (Mn) .42 .21 .23 13 18 29: III 22 47 SULFATE (SO4) 78 90 401 67 CHLORIDE (C1) 24 511 412 330 SPEC. COND. (micromhos/cm) 250 357 100 300 NITROGEN (AMMONIA) 0.03 0.06 0.14 0.22 0.06 0.12 1.3 NITROGEN (NITRATE) 0.9 0.1 0.6 1.2 0.2 .. I PROGEN (NITRITE) <.002 .005 <.002 <.002 .00# <.002 <.02 .32 COPPER (Cu) .26 10. .36 < . 02

Regular

### THE COMMONWEALTH OF MASSACHUSETTS

ne of

# DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING WATER SUPPLY ANALYSIS (mg/per liter)

Wilmington

COLLECTOR Viera

SOURCE A Tub. Wells, Brown's Crossing - 342-01G V SOURCE C SOURCE D " " Town Park Well - 342-04G V SOURCE E " " Shawsheen Ave - 342-05G V SOURCE F " " Salem St. - 342-08G V

MARCH 87

| End Anti-Anti-Anti-Anti-Anti-Anti-Anti-Anti- | A 542 00    | В    | C.   | D    | E        | F    |
|--|-------------|------|------|------|----------|------|
| SAMPLE NO.                                   | 576393      | 394  | 395  | 396  | 397      | 308  |
| DATE OF COLLECTION                           | 3/24/87     | ``   |      |      | <u> </u> |      |
| DATE OF RECEIPT .                            | 3/24/87     |      |      |      |          |      |
| TURBIDITY                                    | 0.6         | 2.6  | 8.5  | 0.3  | 3.9      | 5.0  |
| SEDIMENT                                     | 0           | 0    | 0    | 0    | 0        | 0    |
| COLOR  | 5           | 30   | 20   | 10   | 27       | . 40 |
| ODOR   | 0           | 0    | 0    | 0    | 0 .      | 0    |
| рН   | 6.1         | 7.3  | 6.3  | 6.2  | 6.3      | 6.3  |
| ALKALINITY-TOTAL (CaCO3)                     | 22          | 43   | 36   | 32   | 36       | 29   |
| HARDNESS (CaCO3)                             | 65          | 122  | 77   | 53   | 81       | 57   |
| CALCIUM(Ca)                                  | 19.         | 39.  | 24.  | 15.  | 24.      | 17.  |
| MAGNESIUM (Mg)                               | 4.2         | 5.8  | 4.2  | 3.7  | 5.2      | 3.3  |
| SODIUM(Na)                                   | 47.         | 45.  | 50.  | 18.  | 30.      | 26.  |
| POTASSIUM (K)                                | 2.7         | 3.9  | 3.1  | 2.6  | 3.1      | 2.3  |
| IRON (Fe)                                    | .23         | .33  | 2.3  | .11  | 6.0      | 1.8  |
| MANGANESE(Mn)                                |             | .06  | .47  | .23  | .24      | .56  |
| SULFATE (SO4)                                | 15          | 80   | 40   | 23   | 45       | 18   |
| CHLORIDE (C1)                                | 85          | 72   | 76   | . 26 | 62       | 50   |
| SPEC. COND. (micromhos/cm)                   | 369         | 494  | 406  | 214  | 379      | 289  |
| NITROGEN (AMMONIA)                           | 0.05        | 0.33 | 0.26 | 0.05 | 0.14     | 0,09 |
| NITROGEN (NITRATE)                           | 0.9         | <0.1 | 0.5  | 1,6  | 0.2      | 0.1  |
| ALTROGEN (NITRITE)                           | <.002       | .003 | -005 | .006 | .007     | .006 |
| COMPER(Cu)                                   | <.03        | <.03 | <.03 | .05  | <.03     | .08  |
|  |             | -7   |      |      |          |      |
|  |             |      |      |      |          |      |
|  | <del></del> |      |      |      |          |      |

March 1988

Regular

## THE COMMONWEALTH OF MASSACHUSETTS

## DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING . WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR

D. Smith

SOURCE A Chestnut St. Well - 342-03G SOURCE B G.P. Well, Town Park - 343-04G

SOURCE C " "

Shawsheen Ave. - 342-05G

SOURCE D

Aldrich Well - 342-06G /

A.B.E. F- RAW SUPPLY TO WTP

D- OUT OF SERVICE

|  | A                                     | В     | C                                     | D      | E     | P    |
|--|---------------------------------------|-------|---------------------------------------|--------|-------|------|
| SAMPLE NO.   | 579628                                | 629   | 630                                   | 631    | 632   | 633  |
| DATE OF COLLECTION   | 3/25/88                               |       |                                       |        | -     | •    |
| DATE OF RECEIPT  | 3/25/88                               |       | · · · · · · · · · · · · · · · · · · · |        |       |      |
| TURBIDITY  | 1.2                                   | 5.5   | 0.6                                   | 1.5    | 5.7   | 9.6  |
| SEDIMENT   | . 0                                   | 0     | 0                                     | . 0    | 0     | 0    |
| COLOR  | 35                                    | 40    | 20                                    | 10     | 130   | 90   |
| DOOR   | 0                                     | 0     | 0                                     | 0      | 0     | 0    |
| ol!  | 6.1                                   | 6.0   | 6.1                                   | 6.0    | 6.2   | 6.1  |
| ALKALINITY-TOTAL (CaCO3)   | 26                                    | 31    | 24                                    | 13     | 41    | 32   |
| י איים מינארים איי   | 67                                    | 67    | 45                                    | 33     | 135   | 91   |
| HARDNESS (CaCO3)<br>CALCIUM (Ca)   | 20.                                   | 21.   | 13.                                   | 10.    | 40.   | 27.  |
| MAGNESIUM (Mg)   | 4.1                                   | 3.5   | 3.0                                   | 2.0    | 8.6   | 5.5  |
| SODIUM (Na)  | 41.                                   | 55.   | 18.                                   | -13.   | 69.   | 38.  |
| POTASSIUM (K)  | 3.7                                   | 3.2   | 3.2                                   | 1.3    | 5.0   | 4.0  |
| IRON (Fe)  | .67                                   | 1.1   | .14                                   | .20    | 3.4   | 3.2  |
| MANGANESE (Mn)   | .38                                   | . 45  | .21                                   | .08    | .85   | _27  |
| ALL DE MY IND A S  | 33                                    | 30    | 17                                    | 16     | 46    | 44   |
| SULFATE (504) CHLORIDE (C1)  | 59                                    | 85    | 23                                    | 25     | 110   | 63   |
| SPEC. COND. (micromhos/cm)   | 315                                   | 396   | 192                                   | 153    | 574   | 367  |
| NITROGEN (AMMONIA)   | 0.12                                  | 0.18  | 0.07                                  | <0.02  | 1.38  | 0.14 |
| NITROGEN (NITRATE)   | 0.2                                   | 0.7   | 0.6                                   | 0.5    | <0.1  | 0.3  |
| ALLANGEN (NITRITE)   | <0.002                                | 0.007 | <0.002                                | <0.002 | 0.012 | ი.იი |
| COPPER (Cu)  | <.03                                  | <.03  | <.03                                  | <.03   | <.03  | <.03 |
|  | · · · · · · · · · · · · · · · · · · · | سور   | 1.                                    |        |       |      |
| and the state of t |                                       |       |                                       |        |       |      |

## THE COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

#### WATER SUPPLY ANALYSIS (mg/l)

## PWS ID 3342000



Wilmington CITY/TOWN H. Dailey, George COLLECTOR

SOURCE A Tub Wells - PS Tap - Browns Crossing 342-01G

SOURCE B GP Well - Chestnut St. 342-03G

SOURCE C GP Well - Town Park 342-04G

SOURCE D GP Well - Shawsheen Ave. 342-05G SOURCE E GP Well - Butter's Row 342-07g

| SOURCE E GP Well - Buccel's | KOW 342-07                | 9        |          |          |          |
|-----------------------------|---------------------------|----------|----------|----------|----------|
|                             | Α _                       | В        | 6        | D        | E        |
| SAMPLE NO.                  | 586195                    | 586196   | 586197   | 586198   | 586199   |
| DATE OF COLLECTION          | 05/ <b>3</b> 0/9 <b>0</b> | 05/30/90 | 05/30/90 | 05/30/90 | 05/30/90 |
| DATE OF RECEIPT             | 05/30/90                  | 05/30/90 | 05/30/90 | 05/30/90 | 05/30/90 |
| TURBIDITY                   | 0.4                       | 0.7      | 3.7      | 0.2      | 5.8      |
| SEDIMENT                    | 1                         | 1 :      | 1        | 1        | 0        |
| COLOR                       | 5                         | 35       | 35       | 15       | 60       |
| ODOR                        | 0                         | D1       | 0        | 0        | D1       |
| pH                          | 6.1                       | 6.1      | 6.1      | 6.1      | 6.3      |
| ALKALINITY-TOTAL (CaC03)    | 20                        | 24       | 33       | 31       | 37       |
| PHTH ALKALINITY             |                           |          | ·        | •        |          |
| HARDNESS (CaCO3)            | 64                        | 43       | 74       | 58       | 85       |
| CALCIUM (Ca)                | 19                        | 13       | 23       | 17       | 25       |
| MAGNESIUM (Mg)              | 3.9                       | 2.7      | 4.0      | 3.9      | 5.6      |
| SODIUM (Na)                 | 48                        | 26       | 35       | 22       | 49       |
| POTASSIUM (K)               | 2.8                       | 2.0      | 2.9      | 2.5      | 4.1      |
| IRON (Fe)                   | 0.35                      | 0.25     | 3.5      | 0.25     | 4.9      |
| MANGANESE (Mn)              | 0.59                      | 0.31     | 0.57     | 0.29     | 0.57     |
| SULFATE (S04)               | 14                        | 20       | 29       | 22       | 43       |
| CHLORIDE (Cl)               | 105                       | 44       | 65       | 34       | 70       |
| SPEC. COND. (micromhos/cm)  | 408                       | 239      | 362      | 241      | 402      |
| NITROGEN (AMMONIA)          | 0.07                      | 0.13     | 0.30     | 0.03     | 1.49     |
| NITROGEN (NITRATE)          | 1.27                      | 0.16     | 0.42     | 1.87     | 0.03     |
| NITROGEN (NITRITE)          | <0.002                    | 0.04     | 0.012    | 0.006    | 0.008    |
| COPPER (Cu)                 | 0.04                      | 0.07     | 0.03     | <0.03    | <0.03    |

REMARKS:

## THE COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

## WATER SUPPLY ANALYSIS (mg/l)

PWS ID 3342000

2/190

CITY/TOWN Wilmington COLLECTOR H. Dailey, G

C. Preble

SOURCE A GP Well - Salem St. 342-08G SOURCE B GP Well - #2 Butter's Row 342-09G SOURCE C F H Sargent W T P Finished 342-6

SOURCE C E.H. Sargent W.T.P. Finished 342-09G

SOURCE D

| SOURCE E                   | _                |             |                |   |   |
|----------------------------|------------------|-------------|----------------|---|---|
| ÿ                          | A                | B           | <sub>-</sub> C | D | E |
| SAMPLE NO.                 | 586201.          | 586202      | 586203         |   |   |
| DATE OF COLLECTION         | <b>05</b> /30/90 | 05/30/90    | 05/30/90       | · |   |
| DATE OF RECEIPT            | 05/30/90         | 05/30/90    | 05/30/90       |   |   |
| TURBIDITY                  | 2.6              | <b>5.</b> 6 | 0.1            |   |   |
| SEDIMENT                   | 0                | 0           | 0              |   |   |
| COLOR                      | 35               | 25          | 0              |   |   |
| ODOR                       | 0                | 0           | Cc1            |   |   |
| pH                         | 6.4              | 6.3         | 7.2            |   |   |
| ALKALINITY-TOTAL (CaC03)   | 27               | 33          | 23             |   |   |
| PHTH ALKALINITY            |                  |             |                |   |   |
| HARDNESS (CaCO3)           | 59               | 70          | 81             |   |   |
| CALCIUM (Ca)               | 18               | 21          | 26             |   |   |
| MAGNESIUM (Mg)             | 3.4              | 4.5         | 4.0            |   |   |
| SODIUM (Na)                | 36               | 30          | 48             |   |   |
| POTASSIUM (K)              | 2.7              | 3.1         | 3.1            |   |   |
| IRON (Fe)                  | 2.3              | 5.6         | 0.08           | • |   |
| MANGANESE (Mn)             | 0.72             | 0.26        | <0.03          |   |   |
| SULFATE (SO4)              | 17               | 32          | 24             |   |   |
| CHLORIDE (C1)              | 68               | 55          | 90             | • |   |
| SPEC. COND. (micromhos/cm) | 313              | 341         | 408            |   |   |
| NITROGEN (AMMONIA)         | 0.10             | 0.25        | <0.2           |   |   |
| NITROGEN (NITRATE)         | 0.08             | 0.29        | 0.95           |   |   |
| NITROGEN (NITRITE)         | 0.008            | 0.008       | <0.002         |   |   |
| COPPER (Cu)                | <0.03            | <0.03       | <0.03          |   |   |

REMARKS:

Pegular

## THE COMMONWEALTH OF MASSACHUSETTS



# DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING WATER SUPPLY ANALYSIS (mg/per liter)

|           | Wilmington | • |
|-----------|------------|---|
|           |            |   |
| COLLECTOR | J. Viera   |   |

Butters Row #1 - 342-086 The Plant, Feb. 1989
Salem St. A HOURCE A Tub. Mells, PS Tap - 342-01G HOURCE B G.P. Well, Chestmut - 342-03G OURCE C OURCE D OURCE E " " OURCE F " " " 238 240 241 239 502236 237 SAMPLE NO. 2/13/89 DATE OF COLLECTION 2/13/89 DATE OF RECEIPT 0.5 5.7 7.3 0.5 4.0 3.5 TURBIDITY 7) 0 Ò 0 0 1 SEDIMENT 15 20 1.5 40 30 20 COLOR ٥ 0 0 0 Ö Ö-ODOR 6.2 6.1 6.3 6.3 6.0 6.0 pН 28 30 31 G125 24 ALKALINITY-TOTAL (CaCO3) 0.009 <0.002 0.003 <0.002 0.003 LUEAD (mq/1)<0.002 CC 53 184 66 98 67 HARDNESS (CaCO3) 32. 27. 19. 20. 15. 54. CALCIUM (Ca) 4.2 4.4 12. 3.0 4.3 3.6 MAGNESIUM (Mg) 54. 20. 95. 30. 50. 41. SODIUM (Na) 2.6 2.8 2.3 6.0 2.5 2.6 POTASŠIUM (K) 7.3 .49 6.6 .38 2.6 .69 IRON (Fe) .00 .54 . 34 .42 1.3 .33 MANGANESE (Mn) £2741 24 100 20 16 34 SULFATE (SO4) 95 67 1.05 31 125 70 CHLORIDE (C1) 330 466 219 845 400 338 SPEC. COND. (micromhos/cm) 0.19 0.081 0.09 3.2 0.130.14 NITROGEN (AMMONIA) 1.0 0.2 0.5 0.7 <0.1 I,ONITROGEN (NITRATE) <0.002 0.010 0.000 <0.002 0.002 0.008 NITROGEN (NITRITE) .13 .11 0.3 < .03 < .03 < . 03 COPPER (Cu)

## Water Department

| PΙ | MР | ING | STATISTICS |
|----|----|-----|------------|
|    |    |     |            |

| WATER SUPPLY Maximum Gallons Per Day | 4, 218,000    | 4, <del>450,</del> 000 | $\frac{1983}{4,326,500}$ | 4, <u>1984</u><br>4, <u>228,</u> 700 | 4, <del>193,</del> 300 |
|--------------------------------------|---------------|------------------------|--------------------------|--------------------------------------|------------------------|
| Maximum Gallons<br>Per Week          | 24,887,000    | 26,692,700             | 26,660,900               | 26,093,500                           | 24,598,300             |
| Maximum Gallons<br>Per Month         | 100,441,000   | 101,011,700            | 104,475,400              | 100,396,500                          | 101,415,100            |
| Average Gallons<br>Per Day           | 2,901,976     | 3,772,883              | 2,980,879                | 2,780,674                            | 3,024,474              |
| Average Gallons<br>Per Month         | 88,268,441    | 92,488,167             | 90,668,408               | 84,578,825                           | 91,994,400             |
| Total Gallons<br>Per Year            | 1,059,221,300 | 1,108,858,100          | 1,088,020,900            | 1,014,945,900                        | 1,103,932,800          |
| Annual Rainfall                      | 42.82"        | 46.28"                 | 57.33**                  | 47.61"                               | 36.38"                 |
|                                      | CONSUMPT      | ION STATISTICS -       | GALLONS                  |                                      |                        |
| Residential Use*                     | 352,998,750   | 363,966,930            | 427,627,545              | 413,005,845                          | 408,518,662            |
| Percent of Total                     | 43.0%         | 44.3%                  | 49.5%                    | 50.6%                                | 46.1%                  |
| Industrial Use                       | 466, 973, 085 | 456,183,090            | 435,669,405              | 402,034,245                          | 477,200,640            |
| Percent of Total                     | 56.9%         | 55.6%                  | 50.5%                    | 49.3%                                | 53.8%                  |
| Total Water Metered                  | 819,971,835   | 820,150,020            | 863,296,950              | 815,040,090                          | 885,719,302            |
| Percent of Water Pumped**            | 77.4%         | 73.9%                  | 79.3%                    | 81%                                  | 80.2%                  |

<sup>\*</sup>Residential use includes small commercial users, that is, all water passing through 5/8" meters only.

The Water Treatment Plant supplied approximately 50% of the total water pumped.

## WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1985:

| Street             | Length | <u>Size</u> | <u>Hydrants</u> |
|--------------------|--------|-------------|-----------------|
| Ballardvale Street | 2,080' | 12"         | 5               |
| Research Drive     | 740'   | 12"         | 1               |

<sup>\*\*</sup>The difference between the water pumped and the water metered, 218,213,498 gallons in 1985, represents water used for flushing of water mains, for fires and other hydrant uses, and water lost due to breaks and leakage throughout the system.

ne following new mains were constructed during 1985: (continued)

| Street             | Length          | i | Size | <u>Hydrants</u>   |
|--------------------|-----------------|---|------|-------------------|
| Flagstaff Road     | <del>650'</del> |   | 811  | <del></del> 2     |
| Garden Avenue Ext. | 2521            |   | 6**  | 1                 |
| McGrane Rond       | 3601            |   | 6"   | 1 .               |
| Coral Street       | 3501            |   | 611  | 1                 |
| Cobalt Street      | 270'            |   | 8'1  | 1                 |
| Christine Drive    | 90'             |   | 611  | Hydrant Relocated |
| Kajin Way          | 460'            |   | 811  | 1                 |
| Kajin Way          | 20'             |   | 611  |                   |
| Cary Street        | 40'             |   | 6"   |                   |
| Crescent Street    | 190'            |   | 6"   |                   |
| Broad Street       | 212'            |   | 811  | 1                 |
| Boyle Street       | 600'            |   | 811  | 1                 |
| Albany Street      | 550'            |   | 811  | 1                 |
| Fourth Street      | 5501            | • | 811  | 1                 |
| Lorin Drive        | 520'            |   | 811  | 2                 |
| Tomahawk Drive     | 600'            |   | 811  | 2                 |
| Fairfield Road     | 175'            |   | 611  | $\overline{1}$    |
| Grand Street       | 140'            |   | 611  | ī                 |
| Jacobs Street      | 90'             |   | 611  | ī                 |
| oacous screec      |                 |   |      |                   |
| , · ·              | 8,939           |   |      | 24                |

### \TER

major activity was the initiation of the North Wilmington Water Treatment Plant. The Annual Town Meeting roved \$6.4 million dollars for the construction of a treatment facility for the Salem Street well, Barrows eilfield and the Brown's Crossing wellfield. The plant will be built on the site of the Barrows Pumping tation. The treatment process will be similar to the Butter's Row Treatment Plant. Design of the facility started by Weston and Sampson, Engineers.

- to a reduction in pumping capacity, it was necessary to clean and redevelop three wells.
- er was supplied to Tewksbury on an emergency basis for one month.
- Board was represented on a Regional Planning Group with Reading and North Reading. This group will be orking jointly to protect the groundwater, which is so important to all three towns.
- hur Smith worked with the Task Force that established new regulations regarding underground storage tanks igned to protect the groundwater.

## EWER

procedure for establishing a monitoring system of industrial discharges to the sewer was initiated. This regram will be implemented in 1986 and is designed to protect the sewer pipes from corrosive liquids that an destroy them. Because of the deterioration of a portion of the Eames Street sewer it was necessary to onstruct the portion under the railroad. The work was financed by a court settlement against the alleged

- he Board worked with the Wilmington Housing Authority on the design of the sewer on Cedar Street to service expansion of the Housing for the Elderly on Deming Way.
- ne construction of the Ballardvale Street sewer began, financed by a consortium of firms in the area.
- Board held discussions with firms interested in extending the sewer on Woburn Street.
- assessment from the Massachusetts Water Resources Authority (MDC) increased by 78%. Additional increases an be expected.

H

#### WATER

The design of the North Wilmington Water Treatment was completed. The plans and specifications were approved by the Department of Environmental Quality Engineering. The project will be bid early in 1987. In spite of a State Grant, the financial impact of the debt service will require an increase in water rates in 1987.

A representative of the Board continued participation with the Regional Planning Group with Reading and North Reading.

An application was submitted to the Department of Environmental Quality Engineering for funding the replacement of water mains in North Wilmington.

The Chestnut Street well was cleaned and redeveloped to increase its capacity.

The Water Department Rules and Regulations were revised and updated. In addition, the Special Water Department Charges were increased.

#### SEWER

The Massachusetts Water Resources Authority sewer assessment increased 43% to \$255,000.

Our consultants began updating our Sewer Master Plan.

The industrial discharge monitoring program was initiated. Approximately 40 industries will be tested under this program to verify that they are meeting their discharge permits.

The construction of the Ballardvale Street sewer was completed, financed entirely by private industry.

The contract for the construction of the Cedar Street sewer was signed. This sewer will tie Deming Way Housing for the Elderly into the town's sewer system.

Two (2) applications (Project Information Forms) were submitted to the Division of Water Pollution Control for funding sewer extensions.

The license of one septage hauler to use the septage dumping station was suspended for violation of Sewer Department regulations.

### IN APPRECIATION

After 31 years of service to the Town of Wilmington, our Clerk of the Water and Sewer Department, Sylvia L. Bowman, retired this fall. We wish her a long and happy retirement.

#### PUMPING STATISTICS

|                                      |                           |                          | <del></del> ·      |  |                                    |
|--------------------------------------|---------------------------|--------------------------|--------------------|--|------------------------------------|
| WATER SUPPLY Maximum Gallons Per Day | $4, \frac{1982}{450,000}$ | $\frac{1983}{4,326,500}$ | 4, <u>228,</u> 700 | 4, <del>1985</del><br>4, <del>193,</del> 300 | 1 <u>986</u><br>5, <u>130,</u> 700 |
| Maximum Gallons<br>Per Week          | 26,692,700                | 26,660,900               | 26,093,500         | 24,598,300                                   | 28,474,500                         |
| Maximum Gallons<br>Per Month         | 101,011,700               | 104,475,400              | 100,396,500        | 101,415,100                                  | 110,876,900                        |
| Average Gallons<br>Per Day           | 3,772,883                 | 2,980,879                | 2,780,674          | 3,024,474                                    | 2,966,701                          |
| Average Gallons<br>Per Month         | 92,488,167                | 90,668,408               | 84,578,825         | 91,994,400                                   | 90,320,492                         |
| Total Gallons<br>Per Year            | 1,108,858,100             | 1,088,020,900            | 1,014,945,900      | 1,103,932,800                                | 1,082,845,900                      |

| Total Gallons<br>Per Year      | 1,088,020,900   | 1,014,945,900    | 1,103,932,800 | 1,082,845,900 | 1,185,567,065* |
|--------------------------------|-----------------|------------------|---------------|---------------|----------------|
| *Includes water purchased from | m other systems |                  | •             |               |                |
| Annual Rainfall                | 57.33"          | 47.61"           | 36.38"        | 41.94"        | 38.41"         |
|                                | CONSUMPT        | ION STATISTICS - | GALLONS       | •             |                |
| Residential Use*               | 427,627,545     | 413,005,845      | 408,518,662   | 411,814,446   | (474,675,803)  |
| Percent of Total               | 49.5%           | 50.6%            | 46.1%         | 41.3%         | 40.71%         |
| Industrial Use                 | 435,669,405     | 402,034,245      | 477,200,640   | 469,455,823   | 631,254,953    |
| Percent of Total               | 50.5%           | 49.3%            | 53.8%         | 58.7%         | 59.29%         |
| Total Water Metered            | 863,296,950     | 815,040,090      | 885,719,302   | 881,270,269   | 1,109,869,081  |
| Percent of Water Pumped**      | 79.3%           | 81%              | 80.2%         | 87.54%        | 95.19%         |

<sup>\*</sup>Residential use includes small commercial users, that is, all water passing through 5/8" meters.

The Water Treatment Plant supplied approximately 46.12% of the total water pumped.

## WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1987:

| Street                 | <u>Length</u> |       | <u>Size</u>     | Hydrants         |
|------------------------|---------------|-------|-----------------|------------------|
| Research Road          | 380*          |       | 12"             |                  |
| Fourth Avenue          | 150'          |       | 6 <sup>11</sup> | 1                |
| Fay Street             | 6001          |       | 6''             | ı                |
| Silverhurst Avenue     | 541           |       | 6''             |                  |
| Lee Street             | 150 <b>'</b>  |       | 6''             | 1                |
| Appletree Lane         | 1000          |       | 811             | $\frac{1}{2}$    |
| Cobalt Street          | 2281          |       | 6''             |                  |
| Research Drive         | 1200'         |       | 12"             | 1 Standpipe Line |
| Research Drive         | 9001          |       | 12"             | 3                |
| Patches Pond Lane      | 1200 1        |       | 8"              | 4                |
| Towpath Drive          | 1350 <b>'</b> |       | 8''             | 3                |
| Roosevelt Road         | 350'          | •     | 8"              | 1                |
| Dewey Avenue           | 2001          |       | 611             | 1                |
| Jefferson Road         | 400*          |       | 811             | 1                |
| Albany Street          | 173'          |       | 8"              |                  |
| Factory Road           | 1000'         |       | 6"              | 2                |
| Blanchard Road         | 500 <b>'</b>  |       | 811             | 1                |
| Crescent & Fall Street | 200'          |       | 6"              | 1                |
| Dexter Street          | 180'          |       | 811             |                  |
| Valyn Lane             | 600'          |       | 8''             | 2                |
| Day Street             | <u>450</u> '  |       | 6"              | 1                |
| •                      | 11,265'       |       |                 | <del>26</del>    |
|                        |               | 611   | 3,032           |                  |
|                        |               | 8"    | 5,753           | •                |
|                        |               | 12"   | 2,4801          |                  |
|                        |               | TOTAL | 11,265          |                  |

<sup>\*\*</sup>The difference between the water pumped and the water metered, 75,700,984 gallons in 1987, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

## Water & Sewer Department

### WATER

The Edmund H. Sargent Water Treatment Plant is nearing completion and expects to be in service early 1989. The water main contract relative to the new Water Treatment Plant was awarded to Tornare Construction Corporation and construction was completed this fall except for final paving to be completed in the spring of 1989.

The April 1988 Annual Town Meeting authorized the expenditure of 1.4 million dollars for a 3.0 million gallon water storage tank and connecting water mains. The storage tank is to be located on Town Forest land in North Wilmington.

A "Master Water Plan" is being designed to plan for future water needs into the year 2010.

Water Impact Studies were submitted by all developers for proposed subdivisions or commercial and industrial developments using in excess of 4,000 gallons of water per day. These studies were reviewed to determine the impact of the proposed development on the water requirements of the town.

The Water Department purchased the former "Cranberry Bog" property on Shawsheen Avenue. The land purchased was approximately 60+ acres for \$95,000. This property will allow for future well field development and groundwater protection.

A water rate increase was reflected in the October 1988 water billing. This increase was necessary to cover increased operating costs and bonding for the new water storage tank and connecting water mains.

Unpaid water and sewer charges for 1987, in the amount of \$51,168.30, were committed as liens to the Tax Collector.

### SEWER

The April 1988 Annual Town Meeting authorized the expenditure of \$450,000 for engineering services to design the North/East sewer interceptor. This sewer design should be ready for review in the spring of 1989.

Sewer Master Plan has been updated to conform with zoning changes.

The Jacobs Street sewer has been completed and approved for sewer connections by the residents.

A sewer rate increase was reflected in the October 1988 sewer billing. Most of the sewer rate increase was due to the sewer assessment charges from the Massachusetts Water Resources Authority. Charges for FY-89 are \$389,353.

The Town of Wilmington has been notified by the Massachusetts D.E.Q.E. that all grant monies awarded to the town are currently on "hold" but the State will honor all grants when the monies are available in the State.

It was with many regrets that the Water & Sewer Commissioners accepted the resignations of George R. Allan, Chairman of the Board. George had been a dedicated member of the Board of Water & Sewer Commissioners for 13 1/2 years prior to his resignation October 15, 1988. The Commissioners would like to extend their thanks to George, on behalf of the Board and the Town for his many years of dedicated service, his expertise will be greatly missed. The Town Manager appointed Noel Baratta to fill the vacancy on the Board and Arthur R. Smith, Jr., was elected Chairman of the Board.

| PUMPING | STATISTICS |
|---------|------------|
|---------|------------|

| WATER SUPPLY<br>Maximum Gallons<br>Per Day | $\frac{1984}{4,228,700}$ | 4,1985      | 5,130,700   | 1987<br>4,518,100 | 1988<br>4,912,000 |
|--|--------------------------|-------------|-------------|-------------------|-------------------|
| Maximum Gallons<br>Per Week                | 26,093,500               | 24,598,300  | 28,474,500  | 29,735,500        | 29,811,200        |
| Maximum Gallons<br>Per Month               | 100,396,500              | 101,415,100 | 110,876,900 | 124,240,900       | 120,030,100       |
| Average Gallons<br>Per Day                 | 2,780,674                | 3,024,474   | 2,966,701   | 3,192,664         | 3,245,345         |

| mal Rainfall              | 46. 28"     | 57.33"          | 47.61"      | 36.38"      | 41.94"      |
|---------------------------|-------------|-----------------|-------------|-------------|-------------|
|                           | CONSUMPTI   | ON STATISTICS - | GALLONS     |             | •,          |
| sidential Use*            | 363,966,930 | 427,627,545     | 413,005,845 | 408,518,662 | 411,814,446 |
| rcent of Total            | 44.3%       | 49.5%           | 50.6%       | 46.1%       | 41.3%       |
| dedustrial Use            | 456,183,090 | 435,669,405     | 402,034,245 | 477,200,640 | 469,455,823 |
| ercent of Total           | 55.6%       | 50.5%           | 49.3%       | 53.8%       | 58.7%       |
| Total Water Metered       | 820,150,020 | 863,296,950     | 815,040,090 | 885,719,302 | 881,270,269 |
| Percent of Water Pumped** | 73.9%       | 79.3%           | 81%         | 80.2%       | 87.54%      |

<sup>\*</sup>Residential use includes small commercial users, that is, all water passing through 5/8" meters.

The Water Treatment Plant supplied approximately 63.72% of the total water pumped.

## WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1986:

| <u>Street</u>      | Length  | <u>Size</u> | <u>Hydrants</u> |
|--------------------|---------|-------------|-----------------|
| Pineview Road      | 140'    | 6''         |                 |
| Ballardvale Street | 46'     | 6"          |                 |
| Ballardvale Street | 401     | 8"          |                 |
| Fox Run Drive      | 970'    | 811         | 3               |
| Bailey Road        | 505'    | 8**         | 1               |
| Fairmont Avenue    | 233'    | 6"          |                 |
| Gloria Way         | 848'    | 811         | 2               |
| Wisser Street      | 173'    | 611         |                 |
| Morton Road        | 18*     | 611         |                 |
| St. Paul Street    | 265'    | 6"          | 1               |
| Garden Avenue      | 94 1    | 6"          |                 |
| Everett Avenue     | 4251    | 811         | 1               |
| Marjorie Road      | 2751    | . 611       | 1               |
| Allston Avenue     | 240'    | 611         |                 |
| Lloyd Road         | 100'    | 611         | 1               |
| Fifth Avenue       | 200'    | 8,,         | 1               |
| Reno Road ~        | 400'    | 8''         | 1<br>1<br>1     |
| Gorham Street      | 6001    | 8"          | 1               |
| Chelsea Street     | 441     | 611         |                 |
| Norfolk Avenue     | 185'    | 611         |                 |
| Newbern Avenue     | 300'    | 611         | 1               |
| Plymouth Avenue    | 715'    | 6"          | 1<br>2          |
| Lee Avenue         | 4501    | 6''         | 1               |
| Perry Avenue       | 201     | 611         |                 |
| Ohio Street        | 1150'   | 8"          | 3               |
| Cobalt Street      | 200     | 6**         | 1<br>1<br>1     |
| Winston Avenue     | 4501    | 6''         | 1               |
| Miles Street       | 2501    | 8"'         | 1               |
| Jefferson Road     | 600'    | 811         |                 |
| Research Drive     | 900'    | 12"         |                 |
| Ash St <b>reet</b> | יסס3    | 6"          |                 |
| Melrose Avenue     | 100'    | <u> </u>    | <u></u>         |
| 4.                 | 11,236' |             | <del>23</del>   |
|                    |         | 6'' 4,348'  |                 |
|                    | 4       | 8'' 5,988'  | •               |
|                    |         | 12" 900'    | •               |

Hydrants relocated 1986 - 2 Woburn Street and Keirnan Avenue.

The difference between the water pumped and the water metered, 217,413,631 gallons in 1986, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

# Water & Sewer Department

#### WATER

Bids were received for the Exmand H. Sargent Water Treatement Plant in North Wilmington. The low bid was \$4.9 million. Bids for the connecting water mains will be received in 1988. The State will be providing the Town with a grant of approximately \$2.8 million. A Ground Breaking Ceremony was held on June 6, 1987. It is expected that the plant will be put into service in early 1989.

An aquifer study was initiated to define the Town's aquifer and the recharge areas around our wells.

Inspections were made on our two existing standpipes. Maintenance work will be needed at the Nassau Avenue tank in 1988.

An engineer was hired to undertake a "Water Master Plan Study". In addition, we authorized the design of a new 3 million gallon storage tank to be located in the Town Forest in North Wilmington.

The granular activated carbon at the Butters Row Water Treatment Plant was replaced at a cost of \$41,000.

Water rates were increased on July 1, 1987 to finance the bond payments for the new water treatment plant. This was the first rate increase since 1979. Future rate increases can be expected for future capital expenditures as well as increased operating costs.

New regulations were adopted requiring the submission of a Water Impact Report for any development that exceeds 40,009 gallon per day of water usage. This report will be used to determine the effect the development will have on the Town's water system.

Automatic underground sprinkler irrigation systems were banned for all new construction.

Umpaid water and sewer bills continue to be a problem, averaging \$60,000 annually. It was voted to develop a water service "interruption" policy for delinquent users. The proposed policy is being reviewed by Town Counsel.

Commissioner Maurice "Dice" O'Neil passed away on April 19, 1987. In addition to serving on our Board, he was also a long-time employee of the Water Department, before his retirement in 1981. James A. Ring was appointed by the Town Manager to fill his unexpired term.

#### SEWER

Average Gallons

Per Month

Our updated Sewer Master Plan was completed.

The sewer extension to service the Deming Way Housing Project was put into operation.

Sewer rates were increased, July 1, 1987 in conjunction with the water rate increase.

90,668,408

Our sewer assessment from the Massachusetts Water Resources Authority continues to increase. This year it was \$255,872.00

#### PUMPING STATISTICS WATER SUPPLY 1983 1987 Maximum Gallons 4,326,500 4,228,700 4,193,300 5,130,700 4,518,100 Per Day Maximum Gallons 26,660,900 26,093,500 24,598,300 28,474,500 29,735,500 Per Week Maximum Gallons 104,475,400 100,396,500 101,415,100 110,876,900 124,240,900 Per Month 2,780,674 Average Gallons 2,980,879 3,024,474 2,966,701 3,192,664 Per Day

84,578,825

91,994,400

90,320,492

95,779,920

| Average Gallons                              | 84,578,825    | 91,994,400    | 90,320,492    | 95,779,920    | 98,712,563     |  |  |  |  |  |
|--|---------------|---------------|---------------|---------------|----------------|--|--|--|--|--|
| Per Month<br>Total Gallons<br>Per Year       | 1,014,945,900 | 1,103,932,800 | 1,082,845,900 | 1,185,567,065 | 1,184,550,563* |  |  |  |  |  |
| *Includes water purchased from other systems |               |               |               |               |                |  |  |  |  |  |
| Annual Rainfall                              | 47.61"        | 36.38"        | 41.94"        | 38.41"        | 36.10"         |  |  |  |  |  |
| CONSUMPTION STATISTICS - GALLONS             |               |               |               |               |                |  |  |  |  |  |
| Residential Use*                             | 413,005,845   | 408,518,662   | 411,814,446   | 474,675,803   | 432,331,418    |  |  |  |  |  |
| Percent of Total                             | 50.6%         | 46.1%         | 41.3%         | 40.71%        | 47.64%         |  |  |  |  |  |
| Industrial Use                               | 402,034,245   | 477,200,640   | 469,455,823   | 631,254,953   | 470,317,313    |  |  |  |  |  |
| Percent of Total                             | 49.3%         | 53.8%         | 58.7%         | 59.29%        | 51.83%         |  |  |  |  |  |
| Total Water Metered                          | 815,040,090   | 885,719,302   | 881,270,269   | 1,109,869,081 | 907,415,379    |  |  |  |  |  |
| Percent of Water Pumped**                    | 81%           | 80.2%         | 87.54%        | 95.19%        | 76.60%         |  |  |  |  |  |

<sup>\*</sup>Residential use includes small commercial users, that is, all water passing through 5/8" meters.

The Butters Row Water Treatment Plant supplied approximately 49.64% of the total water pumped.

## WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1988:

| Street           | Amount       | Size             | <u>Hydrants</u> |
|------------------|--------------|------------------|-----------------|
| Research Drive   | 360'         | 1211             |                 |
| Ohio Street      | 135'         | 811              | 1               |
| Tracey Circle    | 700 '        | 811              | 2               |
| Ash Street       | 600'         | 6"               | 1               |
| Ouail Run        | 550 <b>'</b> | 8**              | 1               |
| Earles Row       | 1900'        | 8"               | 3               |
| Allenhurst Drive | 1200 *       | 811              | 3               |
| Mather Street    | 200'         | 8"               | 1               |
| Winston Avenue   | 300'         | 6"               | 1               |
| Fenway Road      | 225'         | 811              | 0               |
| Rollins Road     | 225*         | 8**              | 0               |
| Blanchard Road   | 229'         | 811              | 1               |
|                  | <u>6624*</u> | 900'-6" Main     | 14              |
|                  |              | 5364'-8" Main    |                 |
| ,                |              | 360'-12" Main    |                 |
|                  |              | 6624 TOTAL MAINS |                 |

New water mains constructed in conjunction with E. H. Sargent Water Treatment Plant.

| Salem Street (Route 62)           | 950'    | 8"               | 2  |
|-----------------------------------|---------|------------------|----|
| Woburn Street to WTP I/N Easement | 1860'   | 16"              | 0  |
| Woburn Street to Easement         | 5660'   | 16"              | 4  |
| Brown's Crossing P.S. to Route 62 | 14961   | 12"              | 2  |
| •                                 | 99 66 1 | 950"-8" Main     | 14 |
|                                   | •       | 1496'-12" Main   |    |
|                                   |         | 7520'-16" Main   |    |
|                                   |         | 9966 TOTAL MAINS |    |

Total Water Mains Installed during 1988 - 16,590' or 3.14 miles

<sup>\*</sup>The difference between the water pumped and the water metered, 274,135,372 gallons in 1988, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

# Water & Sewer Department

<u>WATER</u>
The Edmund H. Sargent Water Treatment Plant was put into service on May 2, 1989, with all state approvals being met.

An open house was held on September 16, 1989. The open house was attended by many neighborhood residents and Water Department personnel.

The contracts for the 3.0 million gallon water storage tank and connecting water mains were awarded.

Except for landscaping the tank is complete and was put into full service December, 1989.

The Water Department has obtained the services of a consulting firm to study and prepare "Aquifer Protection Zoning By-Laws" to be adopted at the Annual Town Meeting (1990).

Many "Water Impact Reports" were reviewed for proposed sub-divisions.

Unpaid water and sewer bills for 1988, in the amount of \$52,941.02, were committed as liens to the Tax Collector.

### SEWER

The Northeast Sewer Interceptor design is still ongoing. Survey work on private property is being done where access permission has been obtained.

Nine hundred feet of sewer interceptor has been cleaned in the South Main Street area.

Approximately 2,200 feet of sewer is to be constructed in Main Street, from the junction of Route 38 and Route 129 to Cross Street. Construction is expected to start early 1990.

A sewer rate increase was reflected in the October, 1989 sewer billing. Most of the sewer rate increase was due to the sewer assessment charges from the Massachusetts Water Resources Authority. Charges for FY-1990 are \$660,581.00.

PUMPING STATISTICS

|  |                          |                                      |                             | ***                      |                   |                           |
|--|--------------------------|--------------------------------------|-----------------------------|--------------------------|-------------------|---------------------------|
| WATER SUPPLY<br>Maximum Gallons<br>Per Day | 4, <u>228,</u> 700       | 4, <u>1985</u><br>4, <u>193,</u> 300 | 5, <u>1986</u><br>5,130,700 | <u>1987</u><br>4,518,100 | 1988<br>4,912,000 | 1 <u>989</u><br>4,064,500 |
| Maximum Gallons<br>Per Week                | 26,093,500               | 24,598,300                           | 28,474,500                  | 29,735,500               | 29,811,200        | 22,565,700                |
| Maximum Gallons<br>Per Month               | 100,396,500              | 101,415,100                          | 110,876,900                 | 124,240,900              | 120,030,100       | 97,243,800                |
| Average Gallons<br>Per Day                 | 2,780,674                | 3,024,474                            | 2,966,701                   | 3,192,664                | 3,245,345         | 2,823,110                 |
| Average Gallons                            | 84,578,825               | 91,994,400                           | 90,320,492                  | 95,779,920               | 98,712,563        | 85,869,600                |
| Per Month                                  | 1,014,945,900            | 1,103,932,800                        | 1,082,845,900               | 1,185,567,065            |                   | 1,030,435,200*            |
| *Includes water<br>Annual Rainfall         | purchased from<br>47.61" | other systems<br>36.38"              | 41.94*                      | 38.41"                   | 36.10"            | 42.66*                    |
|  |                          | CONSUMPT                             | ION STATISTICS -            | <u>GALLONS</u>           |                   |                           |
| Residential Use*                           | 413,005,845              | 408,518,662                          | 411,814,446                 | 474,675,803              | 432,331,418       | 403,228,522               |
| Percent of Total                           | 50.6%                    | 46.1%                                | 41.3%                       | 40.71%                   | 47.64%            | 39%                       |
| Industrial Use                             | 402,034,245              | 477,200,640                          | 469,455,823                 | 631,254.953              | 470,317,313       | 457,822,530               |
| Percent of Total                           | 49.3%                    | 53.8%                                | 58.7%                       | 59.29%                   | 51.83%            | 44%                       |
| Total Water<br>Metered                     | 815,040,090              | 885,719,302                          | 881,270,269                 | 1,109,869,081            | 907,415,379       | 857,301,052               |

rcent of Water
Pumped\*\*

81%

80.2%

87.54%

95.19%

76.60%

83%

Residential use includes small commercial users, that is, all water passing through 5/8" meters.

The difference between the water pumped and the water metered, 173,134,148 gallons in 1989, represents water used for flushing of water mains, flushing and filling new water mains, for fires, street sweeping and other hydrant uses, testing new water treatment plant before acceptance by department and water lost due to in breaks.

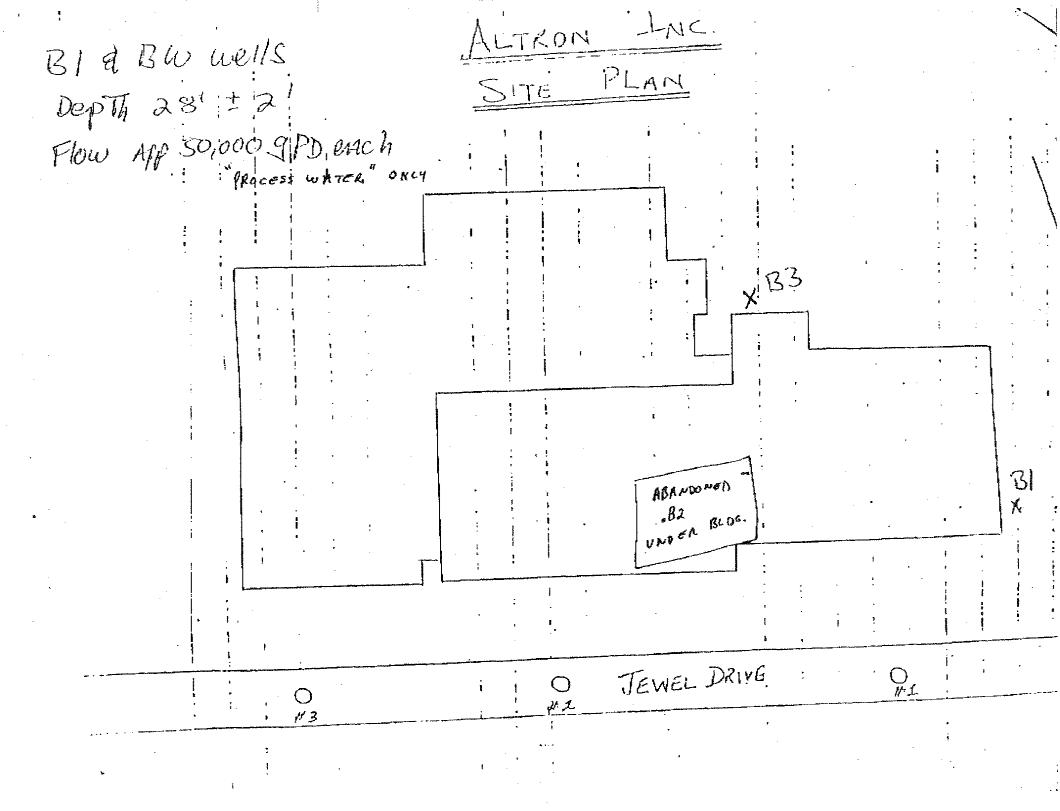
## JATER DISTRIBUTION SYSTEM

e following new mains were constructed during 1989:

| <u>Street</u>                    | Amount       | <u>Size</u> | <u>Hydrants</u> |
|----------------------------------|--------------|-------------|-----------------|
| Olmstead Avenue                  | 375 <i>'</i> | 6"          | 1               |
| Marrietta Avenue                 | 750 <i>*</i> | 8"          | 2               |
| Pearl Court                      | 225′         | 611         | 0               |
| Crystal Road                     | 950 <i>*</i> | 8**         | 3               |
| Whitefield Elms                  | 1650'        | 12"         | 5               |
| Andover Street                   | 475′         | 12"         | . 1             |
| Dunmore Road                     | 300 <i>°</i> | 64          | 1               |
| Waltham Street                   | 370 <i>*</i> | 6"          | 1               |
| Upton Court                      | 240'         | 12"         | 0               |
| Hall Street                      | 1237         | 811         | 1               |
| Dewey Avenue                     | 200"         | 6#          | 0               |
| Naples Road                      | 300'         | 6#          | 1               |
| Second Avenue                    | 1275′        | 8 11        | 3               |
| Dunton Road                      | 2341         | 64          | 1               |
| Clark Terrace                    | 242*         | 6"          | 1               |
| New Hampshire/Rand/Garvin Road   | 21001        | 8#          | 4               |
| Cristo/Vermont Road              | 7001         | 8"          | 2               |
| Amherst Road                     | 1500'        | 8"          | 2               |
| Henry L. Drive                   | 6001         | 8"          | $\bar{2}$       |
| Lynch Road                       | 2681         | 8"          | 1               |
| Buckingham Road                  | 450'         | 84          | i               |
| Allgrove Estates                 | 9001         | B11         | 3               |
| Cross country for new water tank | 3,100′       | 12"/16"     | 1               |
| Total                            | 17,327       | ,           | •               |

tal water mains installed during 1989 - 17,327' or 3.14 miles there have been 41 new hydrant added to the system

ALTON WELL LOGS/ AVAILABLE DATA



IL AAIA OL CILL ATTERTURI 7115 LIMIT LOCATION Right front corner of building looking from Test have Lon EPTH OF FORMATION FOUND EACH STRATUM TRATIM DIA. TEST WE 01-81 medium to coarse sand & gravel with STATIC WL FF large boulders STATIC WL FR 81-541 brown medium to coarse sand TOTAL DEPTH 341-671 gray medium to coarse sand DEPTH DEVEL 67 \* REFUSAL PIPE LEFT IN I TYPE SCREEN DEPTH SCREE DEVELOPED & Pumped 40 gpm at 66° with green water 30 G.P. WATER SAMPL and high iron Pulled back to 57' with high iron DATE COLLEC Pulled back to 30' and developed ord of pumping test to determine specific yield nped\_\_\_gp.m for\_hr. from\_\_\_\_abserved\_\_ft.\_in, drawdown in abs.\_\_ft. away at a de nped\_\_\_\_a.p.m for\_hr.fram\_\_\_\_observed\_\_ft\_in, drawdown in obs\_\_\_ft.away at a de Specific yield of gallons per foot of drawdown

SIGNED\_\_\_

II driven by L. N. Osborne

BI Well

| FORMATION FOUR TOWN wed. to coar cown med. to coar cown fine to wed. to trefusal - high ack to 25' and se | ND EACH se sand & se sand & se sand & sand iron con | STRATUNG gravel is gravel itent - p  | free free free oulled  | STATIC WL<br>STATIC WL<br>TOTAL DEF<br>DEPTH DEV   | FROM TOP P FROM GROUP PTH DRIVEN VELOPED IN PLACE   | 25'   |
|---|---|--|--|--|---|---|
| rown med. to coar cown med. to coar cown fine to med. ot refusal - high mak to 25' and se                 | se sand & se sand & sand iron con t screen          | gravel gravel tent - p & develo  | free free free oulled  | STATIC WL<br>STATIC WL<br>TOTAL DEF<br>DEPTH DEV   | FROM TOP P FROM GROUP PTH DRIVEN VELOPED IN PLACE   | 36°<br>25°  |
| cown rel. to coar cown fine to wed. ot refusal - high ack to 25' and se                                   | sr sand 6 sand iron con t screen                    | s gravel<br>ntent - p<br>& develo  | free free oulled   | STATIC WL<br>STATIC WL<br>TOTAL DEF<br>DEPTH DEV   | FROM TOP P FROM GROUP PTH DRIVEN VELOPED IN PLACE   | 36°<br>25°  |
| cown rel. to coar cown fine to wed. ot refusal - high ack to 25' and se                                   | sr sand 6 sand iron con t screen                    | s gravel<br>ntent - p<br>& develo  | free free oulled   | STATIC WL<br>STATIC WL<br>TOTAL DEF<br>DEPTH DEV   | FROM TOP P FROM GROUP PTH DRIVEN VELOPED IN PLACE   | 25'   |
| cown fine to med.  ot refusal - high  ock to 25' and se   | iron con  | ntent - p<br>& develo  | free<br>oulled<br>oped   | STATIC WL<br>TOTAL DEF<br>DEPTH DEV<br>PIPE LEFT   | PROM GROUN<br>PTH DRIVEN<br>VELOPED<br>IN PLACE   | 25'   |
| nck to 25' and se   | t screen  | & develo   | ped  | PIPE LEFT  | N PLACE   | 25 '<br>18 '  |
| nck to 25' and se   | t screen  | & develo   | ped  | PIPE LEFT  | N PLACE   | 18'   |
| Jote high   | Iron L  | nkn  | <b>/</b>   | 1  | <del></del>   |   |
| Vote high   | Iron C  | nkn  | <b>#</b>   | TURE   | TEN TIAN  | Gal. Joh  |
| J   |   |  |  | THE SCRE   | EN 1 1/4"   | log   |
|   |   | والمراجع والمستوالة والمراجع  |  | DEPTH SCI  | reen set <sub>20</sub>  | 0'-25'  |
|   |   |  | ············   | i .  | ) ¢ rated a   |   |
|   |   |  |  | description of the second second   | G.P.M. 15"  | VAC.  |
|   |   |  |  | WATER SA   | MPLE  | •   |
|   |   |  |  | DATE COL   | LECTED  |   |
|   |   | · · · · · · · · · · · · · · · · · · ·  |  |  | REMARKS   |   |
|   |   |  | Andrew State (State State Stat | The state of the s |   |   |
|   |   |  |  |  |   |   |
|   | man and a second                                    | and all and a second with  | A N  |  |   |   |
| test to determine spe   | cffic yield   | The state of the s | = a =  |  | •   |   |
| c_hr. fromobser   | ved_fi_in,  | , drawdown ti<br>, drawdown ii   | n obs  | - frieway -at  |   |   |
| yiew of gallone   | per toot  | of drawdo  | <b>*</b> 0   |  |   |   |
|   |   | A CONTRACTOR OF THE PARTY OF TH |  |  | •   | 6   |
|   | r_2hr. frombbser<br>chr. fromobser                  | for for the from #2 boserved from boserved from posserved from yield of gallane per foot   | for 2nd mine specific yield  for 2nd mine  | for 2nd mineral to 2n | test to determine specific yield  for 2nd mineral test  2 hr. from #2 observed not in, drawdown in obsfr. away of  yield ofgallone per foot of drawdown | test to determine specific yield  for 2nd mineral test  2ik from #2 baserved from trawdown in obs. froway of a depth of yield in gallone per foot of drawdown |



VVAIEK AINALTOID LADURALURI longure Technologies Corporation

10 Technology Drive, Lowell, Massachusetts 01851 (800) 783-PURE (508) 934-9349

March 19, 1992

AGJC50883904 010430H

JOSEPH DATTILO WT MANAGER ALTRON, INC 1 JEWEL DRIVE WILMINGTON

MA 01887

CUSTOMER NAME:

JOSEPH DATTILO

CUSTOMER COMPANY:

ALTRON, INC

CUSTOMER CITY/STATE:

SAMPLING DATE:

WILMINGTON
10-MAR-92

SAMPLE DESCRIPTION:

Bl WELL

WATER SAMPLE SOURCE:

DT WEDD

BILLING INFORMATION:

RAW PRIVATE WELL WATER

MA

7 1

PURCHASE ORDER NUMBER

229307-62

IONPURE ID NUMBER:

920532

TEST:

RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

|  |       | CAT   | IONS   |       | ANIONS   |  |
|--|-------|---|--|-------|--|--|
|  | •     | PPM IONS  | PPM CaCO   | 3     | PPM IONS   | PPM CaCO3  |
| Ca<br>Mya<br>K e u<br>BMR<br>Srl<br>Al |       | 19.07<br>4.11<br>75.70<br>2.55<br>0.011<br>0.01<br>0.05<br>0.950<br>0.14<br>0.036 | 47.67<br>16.93<br>165.03<br>3.26<br>0.03<br>0.02<br>0.04<br>1.73<br>0.16 | •     | 0.00<br>0.00<br>29.27<br>188.20<br>116.40<br>13.20<br>0.00 | 0.00<br>0.00<br>24.00<br>195.73<br>164.12<br>10.69<br>0.00 |
| TOT.                                   | AL    |   | 235.07   | TOTAL |  | 394.54   |
|  | SiO2  | (PPM SiO2)  | 10.39  | SiO   | 2 (PPM AS C  | (aCO3) E.£3  |
|  | TOTAL | HARDNESS P  | PM AS CACDE  |       |  | 64.61  |
|  | TOTAL | ALKALINITY  | PPM AS CaCO3   |       |  | 24.00  |
|  | CARBO | N DIOXIDE P   | PM AS CaCO3  |       |  | 45.26  |
|  | pH (U | NITS)   |  |       |  | ć. <u> </u>  |

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM AMMONIA = 53.7 PPM

NOTEL: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

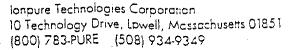
THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

Steven Fr. Boyer

CERTIFIED LABORATORY MAO70
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION





March 19, 1992

MGJC50884140 010430H

JOSEPH DATTILO WT MANAGER ALTRON, INC 1 JEWEL DRIVE WILMINGTON

MA 01887

CUSTOMER NAME:

JOSEPH DATTILO

CUSTOMER COMPANY: ALTRON, INC

CUSTOMER CITY/STATE: WILMINGTON

MA

SAMPLING DATE:

10-MAR-92

SAMPLE DESCRIPTION:

B1 CITY

WATER SAMPLE SOURCE: RAW MUNICIPAL WELL WATER

BILLING INFORMATION: PURCHASE ORDER NUMBER 229307-62

IONPURE ID NUMBER:

920530

TEST:

RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

|   |         | CA  | TIONS     |  |  |      |             |  | ANIONS |     |   |
|---|---------|---|-----------|--|--|------|-------------|--|--------|-----|---|
|   | PP      | M IONS  | PDW       | CaCO3  |  |      | PPM         | IONS   |        | PPM | CaCO3   |
| Ca<br>Mg<br>Na<br>K e<br>U aa<br>Mn<br>Sr<br>Al |         | 32.10<br>4.14<br>31.85<br>2.90<br>0.008<br>0.04<br>0.02<br>0.014<br>0.10<br>0.028 |           | 80.25<br>17.06<br>69.43<br>3.71<br>0.02<br>0.06<br>0.01<br>0.03<br>0.11<br>0.156 | OH<br>CO3<br>HCO3<br>SO4<br>Cl<br>NO3<br>F |      | 3<br>6<br>5 | 0.00<br>0.00<br>9.02<br>1.50<br>2.80<br>2.90 |        | 6   | 0.00<br>0.00<br>32.00<br>53.96<br>74.45<br>2.35<br>0.00 |
| TOTA  | AL      |   | 1         | 70.84  | TOTA                                       | .L   |             |  |        | 1.  | 72.76   |
|   | SiC2 (  | PPM Sic2  | ) 10.     | . 27   |  | 5102 | (PPM        | ! AS   | CaCO3) |     | 8.52  |
|   | TOTAL H | ARDNESS   | PPM AS Ca | aCO3   |  |      |             |  |        | ;   | 97.31   |
|   | TOTAL A | LKAL IN IT  | Y PPM AS  | CaCO3  |  |      |             |  |        |     | 32.00   |
|   | CARBON  | DIOXIDE   | PPM AS Ca | <b>1</b> C03   |  |      |             |  |        |     | 2.24  |
|   | ph (UNI | TS)   |           | •  |  |      |             |  | •      |     | 7.5   |

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM AMMONIA = 0.21 PPM

NOTEL: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MAO70
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION



WATER ANALYSIS LABORATORY

lonpure Technologies Corporation 10 Technology Drive, Lowell, Massachusetts 01851 (800) 783-PURE (508) 934-9349

March 19, 1992

NGJC50883889 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON

MA 01887

CUSTOMER NAME:

JOSEPH DATTILO

CUSTOMER COMPANY:

ALTRON, INC

CUSTOMER CITY/STATE:

WILMINGTON MA

SAMPLING DATE:

10-MAR-92

SAMPLE DESCRIPTION:

B3 WELL

WATER SAMPLE SOURCE:

RAW PRIVATE WELL WATER

BILLING INFORMATION:

PURCHASE ORDER NUMBER

229307-62

ANIONS

IONPURE ID NUMBER:

920531

CATIONS

TEST: RO/CDI T

RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

|   | W111 10110 |   |              |                               | *****  | -      |  |  |
|---|------------|---|--------------|-------------------------------|--|--------|--|--|
|   | F          | PM IONS   | PPM CaCO3    |                               | PPM IONS   | P      | PM CaCO3   |  |
| Ca<br>Mg<br>Na<br>K<br>Fe<br>Ou<br>Ba<br>Mn<br>Sr<br>Al |            | 20.10<br>4.18<br>85.40<br>4.44<br>0.027<br>0.07<br>0.04<br>3.640<br>0.15<br>0.038 | 0.11<br>0.03 | HCO3<br>SO4<br>C1<br>NO3<br>F | 0.00<br>0.00<br>19.51<br>85.10<br>126.40<br>5.80<br>0.00 |        | 0.00<br>0.00<br>16.00<br>88.50<br>178.22<br>4.70<br>0.00 |  |
| TOT   | AL         |   | 266.55       | TOTAL                         |  |        | 287.43   |  |
|   | SiO2       | (PPM SiO2)  | 9.79         | SiO2                          | (PPM AS  | CaCO3) | 8.12   |  |
|   | TOTAL      | HARDNESS S  | PPM AS CaCO3 |                               |  | •      | 67.47  |  |
|   | TOTAL      | ALKALINITY  | PPM AS CaCO3 |                               | ,  |        | 16.00  |  |
|   | CAREO      | 4 DIOXIDE P   | PPM AS CaCO3 | •                             |  |        | 61.12  |  |
|   | pH (U)     | NITS)   | •            |                               |  |        | ≡.€  |  |

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM AMMONIA = 9.6 PPM

NOTEL: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

Steven Fr. Boyer

CERTIFIED LABORATORY MAO70
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION



ママン・ロス チェットこうこう トラケクラン・ラン・ Ionpure Technologies Corporation 10 Technology Drive, Lowell, Mossachusens 01851 (800) 783-PURE (508) 934-9349

March 19, 1992

IGJC50884556 010430H

JOSEPH DATTILO WI MANAGER ALTRON, INC 1 JEWEL DRIVE WILMINGTON

MA 01887

CUSTOMER NAME:

JOSEPH DATTILO

CUSTOMER COMPANY:

ALTRON, INC

CUSTOMER CITY/STATE:

WILMINGTON MA

SAMPLING DATE:

SAMPLE DESCRIPTION:

10-MAR-92

B3 CITY

WATER SAMPLE SOURCE:

RAW MUNICIPAL WELL WATER

EILLING INFORMATION:

PURCHASE ORDER NUMBER

229307-62

ANIONS

IONPURE ID NUMBER:

920529

CATIONS

TEST:

RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

|  |        |      |  |       | £ 24 t w w 4 t w  |                              |      |        |   |        |        |   |
|--|--------|------|--|-------|---|------------------------------|------|--------|---|--------|--------|---|
|  | F      | PM   | IONS   | E     | PM Caco   | 3                            |      | PPM    | IONS  |        | PPM    | CaC03   |
| Ca<br>Mg<br>Na<br>Ke<br>Cu<br>Ba<br>Mn<br>Sr<br>Al |        | 3    | 2.30<br>4.28<br>4.58<br>2.75<br>0.043<br>0.03<br>0.01<br>0.013<br>0.10 |       | 80.75<br>17.63<br>75.38<br>3.52<br>0.12<br>0.05<br>0.01<br>0.02<br>0.11 | HCO<br>SO4<br>C1<br>NO3<br>F |      | 3<br>6 | 0.00<br>0.00<br>39.02<br>50.70<br>55.90<br>2.90<br>0.00 |        | e<br>e | 0.00<br>0.00<br>32.00<br>53.13<br>78.52<br>2.35<br>0.00 |
| TOTA   | LL.    |      |  |       | 177.77  | TOT.                         | AL   |        |   |        | 17     | 76.30   |
|  | SiO2   | (PP  | M SiO2)  |       | 9.53  |                              | Sio2 | (PP    | 4 AS  | CaCC3) |        | 7.91  |
|  | TOTAL  | HAR  | DNESS P  | PM AS | CaCO3   |                              |      |        |   |        | 9      | 9a.3a   |
|  | TOTAL  | ALK  | ALINITY  | PPM A | AS CaCD3  |                              | ·    |        |   | -      | •      | 32.00   |
|  | CAREON | 1 DI | OXIDE P  | PM AS | CaC03   | •                            |      |        |   |        | ·      | 2.24  |
| /  | pH (U) | ITS  | ÷  | •     |   |                              |      |        |   |        |        | 7.5   |

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM AMMONIA = 0.34 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

Steven Fr. Boyer

CERTIFIED LABORATORY MAG70
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

# APPENDIX B

## APPENDIX B

LGI MAGNETOMETER SURVEY REPORT



PROJECT #44,2259

## GEOPHYSICAL INVESTIGATION

AT THE

OLIN CHEMICAL FACILITY WILMINGTON, MASSACHUSETTS

PREPARED FOR

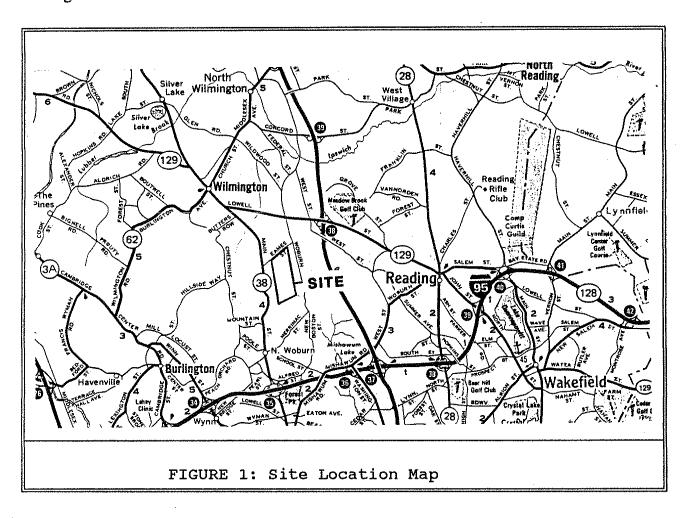
CONESTOGA - ROVERS 651 COLBY DRIVE WATERLOO, ONTARIO, CANADA N2V1C2

JANUARY 1991



## 1.0 OVERVIEW

On December 10<sup>th</sup>-14<sup>th</sup>, 17<sup>th</sup>-19<sup>th</sup>, 1990 and January 7<sup>th</sup> & 8<sup>th</sup>, 1991, LGI, a division of Layne GeoSciences, Inc., performed a magnetic investigation at the Olin Chemical facility in Wilmington, Massachusetts (see Site Location Map). The purpose of the investigation was to locate and delineate the extent of any buried drums and tanks within the two study areas. At the request of the client, a magnetometer survey was selected for the geophysical investigation.





## 2.0 METHODOLOGY AND FIELD DESIGN

## 2.1 Theory and Instrumentation

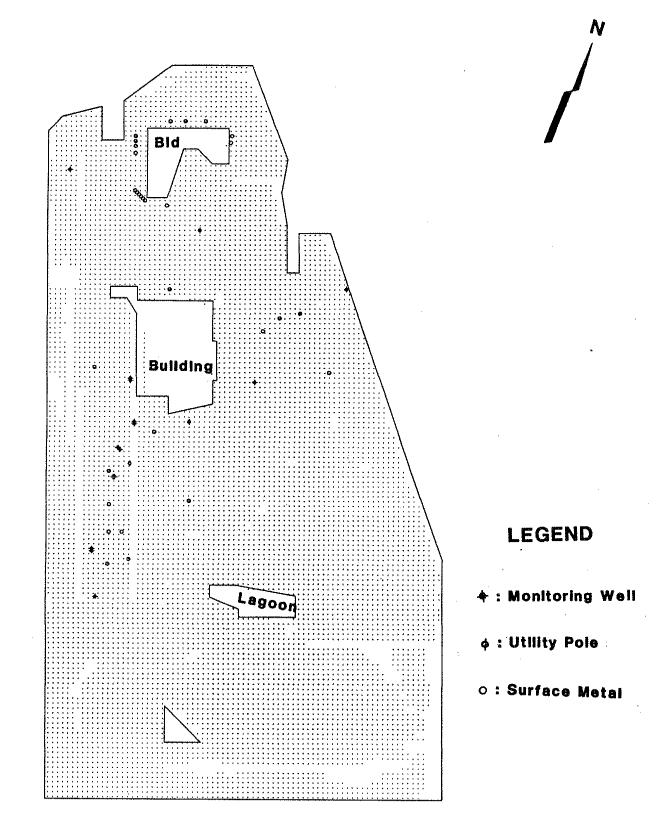
The magnetic method is a non-destructive, non-invasive geophysical technique used to detect local perturbations in the earth's magnetic field caused by buried ferromagnetic objects. A magnetometer is the device utilized to measure the earth's natural magnetic field. The earth's magnetic (geomagnetic) field induces magnetization in magnetically susceptible objects/materials. The presence of such an object in the natural magnetic field alters the field in both magnitude and direction. This induced magnetic field is superimposed on the geomagnetic field, giving rise to regions of anomalous behavior. This behavior is dependent on several variables, including target to sensor distance, target material, target mass, geometry, and orientation.

For this investigation, LGI utilized a GEM-2 proton precession dual magnetometer system or gradiometer configuration. The gradiometer system consists of two proton precession magnetometer sensors separated vertically by 56cm. This gradiometer configuration permits an instantaneous determination of the total magnetic field over a fixed vertical distance. The advantages of this technique are the ability determine vertical field gradient while being relatively insensitive to the horizontal gradient component, and eliminates the need to re-occupy a base station. Base station re-occupation is required to correct for natural time varying magnetic field changes (diurnal variations). Because the gradiometer instantaneous differences between two sensors, the effect of the diurnal variation is canceled. The features of this configuration furnish desireable characteristics when exploring for shallow subsurface targets, and not when assisting in geologic structure interpretation.

## 2.2 Field Design

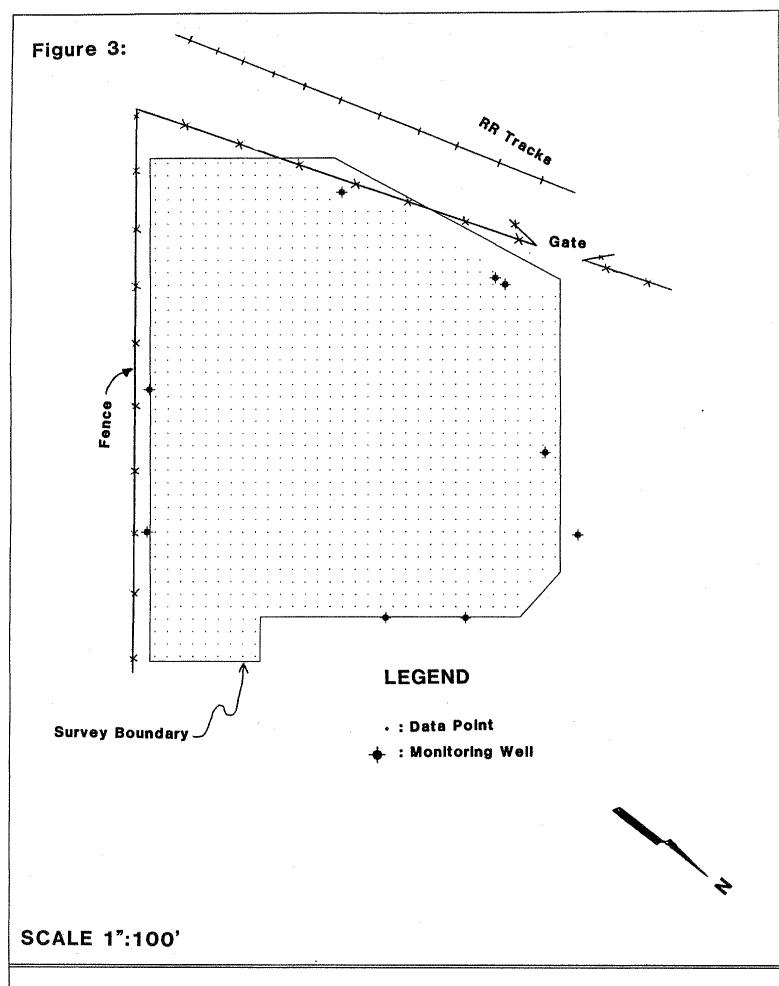
In total, approximately 9,800 geophysical data points were collected. Two regions, covering a combined area of nearly twenty acres were designated for the gradiometer survey. The two areas encompassed the sulfate landfill, the building and operations area, and the former lagoon area. A 50'x50' control grid was established by a surveyor furnished by the client. LGI "filled-in" the control grid to complete a 25'x25' arrangement and data was collected on a 12.5' grid pattern by bisecting the new 25'x25' grid. Locations of scrap, monitoring wells, and other potential sources of magnetic interference were noted by the project geophysicist during the course of data collection (see Figures 2 & 3).

Figure 2:



SCALE 1":200'

# DATA REFERENCE MAP



DATA REFERENCE MAP - LANDFILL



### 4.0 DATA INTERPRETATION AND RESULTS

Values for the magnetic gradient and the lower magnetometer sensor were recorded by the GEM-2 system and downloaded to a computer. Maps of the Total Magnetic Field and Magnetic Gradient for each area were created by smoothing, filtering, and contouring the data with the aid of a computer (see Figures 4 - 8).

The results of the gradiometer investigation indicated that there are strong anomalous features within the study areas. Interpreted anomalies have been delineated and posted on the Magnetic Gradient Interpretation Maps. The following symbol coding scheme has been applied to Figures 9 & 10:

| Symbol Code        | Interpretation   |  |  |  |  |  |
|--------------------|--|--|--|--|--|--|
| RED Hashed Area    | Possible buried drum or group of drums; anomaly shows the characteristics of a large ferromagnetic object. |  |  |  |  |  |
| YELLOW Hashed Area | Buried ferromagnetic object(s); orientation may indicate cultural source.                                  |  |  |  |  |  |
| GREEN Hashed Area  | Known feature; scrap at surface, monitoring well, building, etc.   |  |  |  |  |  |

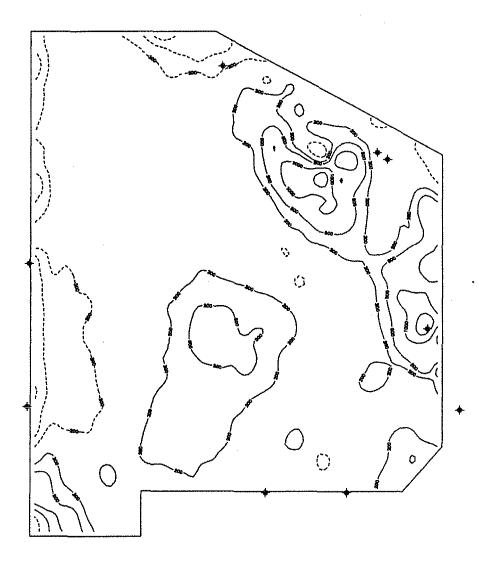
The large anomalies (indicated in red) are extremely strong in magnitude implying that the source is relatively shallow (less than 10' deep) and large. Yellow anomalies are oriented in a manner that suggests a cultural source (utilities, etc.). These areas should be considered suspicious if no utilities are known to exist in these areas. While the anomalies indicated in green surround known features (buildings, foundations, wells, etc.), it does not preclude the existence of drums or other metallic objects buried beneath or in close proximity to the feature. In addition, It was also noted during the course of data collection that magnetic values were influenced while traversing large rock outcrops. Although these effects are relatively minor, they may produce sizeable anomalies.

Due to the presence of strong external magnetic noise in the northern portion of the site, anomalies in this area can only be attributed to the known surface features. Therefore, subsurface features of concern in this area can not be interpreted from the magnetic data alone. LGI recommends that these areas, in addition to all yellow and red coded anomalies be investigated further. The ground penetrating radar (GPR) method provides excellent information concerning the size and depth of subsurface features. This geophysical method is also a non-destructive, non-invasive means of examining subsurface targets.

Figure 4: SCALE 1":250' Values are -55000

**TOTAL MAGNETIC FIELD MAP** 

Figure 5:



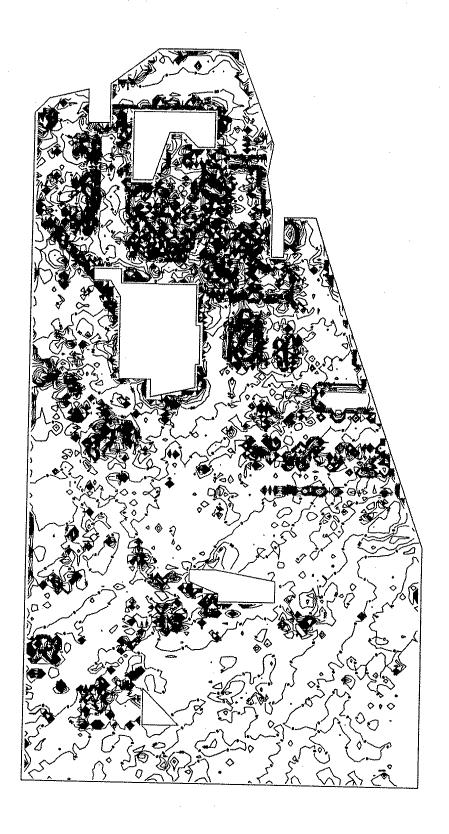


SCALE 1":100'

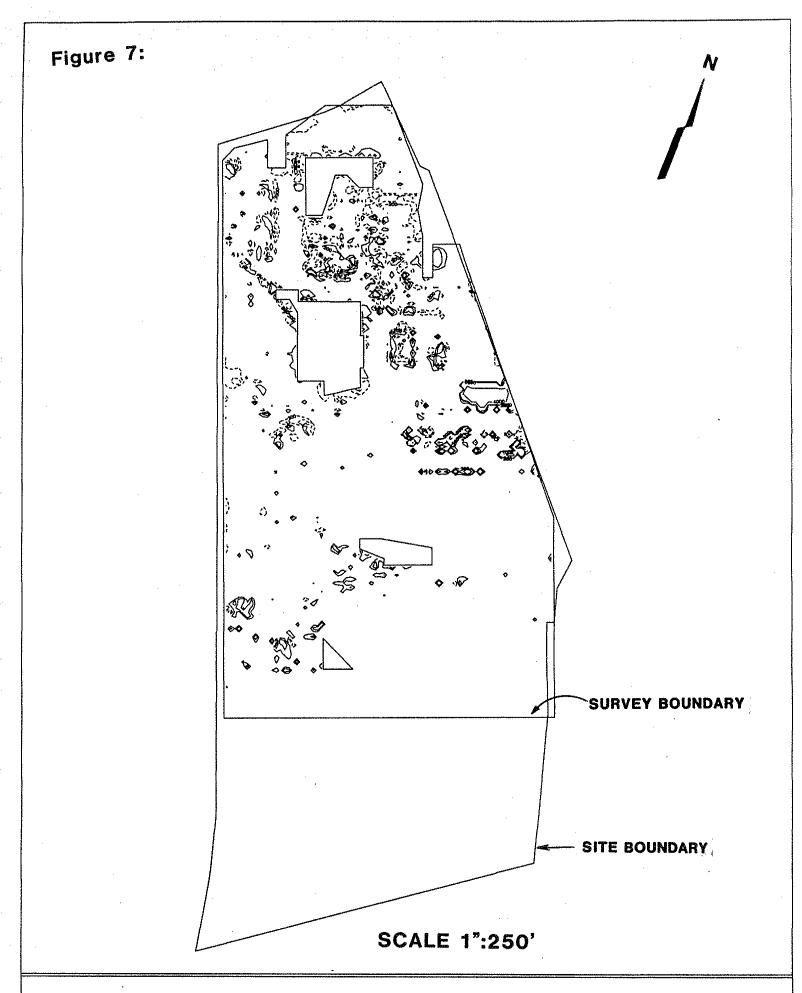
Values are -55000

TOTAL MAGNETIC FIELD MAP - LANDFILL

Figure 6:

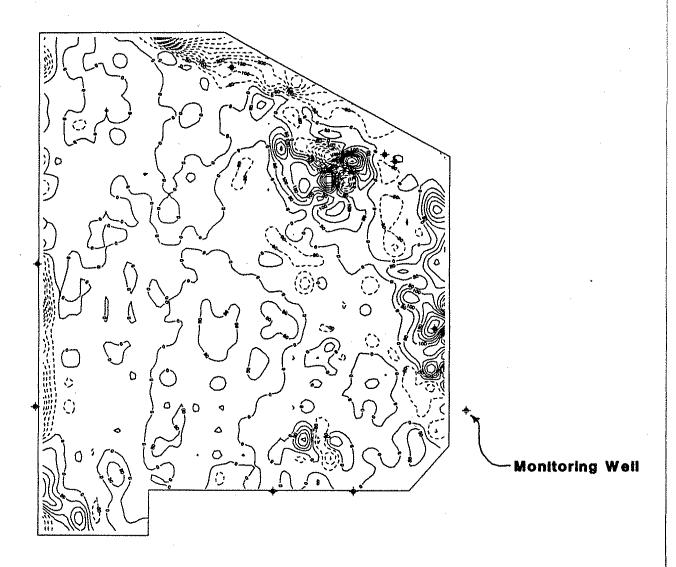


SCALE 1":200'



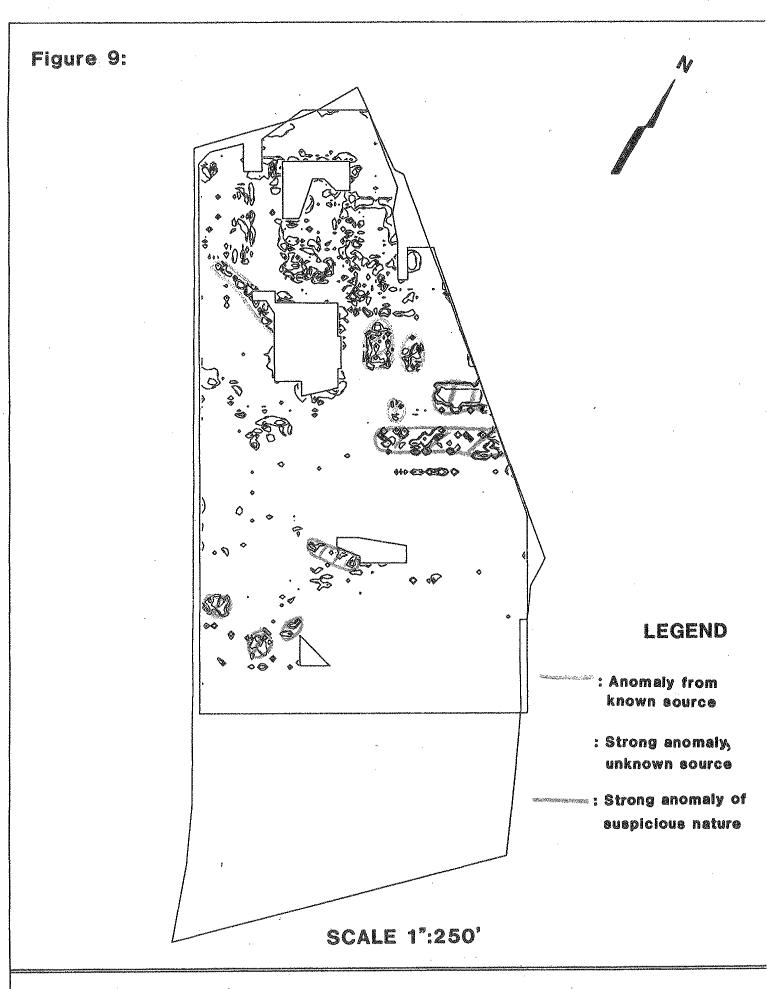
**MAGNETIC GRADIENT MAP - Filtered for Interpretation** 

Figure 8:





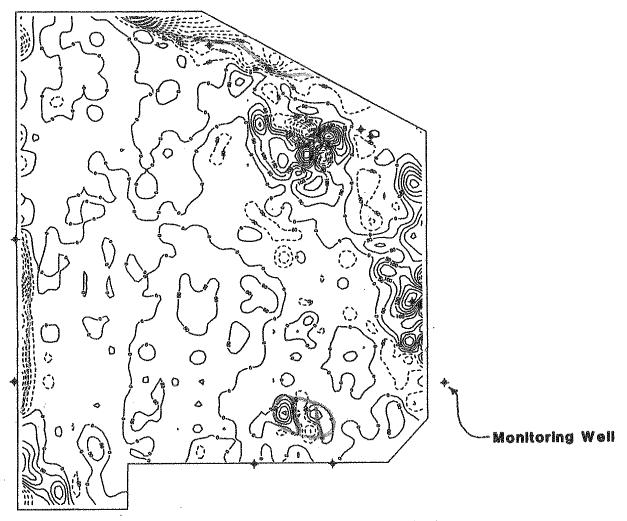
SCALE 1":100'



MAGNETIC GRADIENT INTERPRETATION MAP

## Figure 10:

## INTERPRETATION



- : Anomaly from known source
- : Strong anomaly, unknown source
- Strong anomaly of suspicious nature





## 6.0 CLOSING

The field procedures and interpretative methodologies used in this project are consistent with standard, recognized practices in geophysical investigations. The correlation of geophysical anomalies with probable subsurface features is based on the past result of similar surveys although it is possible that some variation could exist at this site. This warranty is in lieu of all other warranties either implied of expressed. LGI assumes no responsibility for interpretations made by others based on work performed by or recommendations made by LGI.

# APPENDIX C

# APPENDIX C LGI SOIL GAS SURVEY REPORT



# Project 44.2773

# **SOIL GAS SURVEY**

### at the

#### **OLIN FACILITY**

# WILMINGTON, MASSACHUSETTS

# FEBRUARY/MARCH 1992

# Prepared for:

Conestoga-Rovers & Associates Limited 1801 Old Hwy. 8, Suite 114 St. Paul, Minnesota 55112



6 Penn Highway • Sinking Spring, Pennsylvania 19608 • 215/670-5900 • 215/670-5903 (FAX)

April 8, 1992 Project #44.2773

Mr. Jon Michels
Conestoga-Rovers & Associates Limited
1801 Old Hwy. 8, Suite 114
St. Paul, Minnesota, 55112

Subject:

Soil Gas Survey at the Olin Facility in Wilmington, Massachusetts.

Dear Jon:

LGI, a division of Layne GeoSciences, Inc., is pleased to present the results of a soil gas survey of two (2) warehouse buildings at the Olin facility in Wilmington, Massachusetts. The survey was conducted in an attempt to delineate regions under the warehouses which may characterize buried drum waste.

# 1.0 SOIL GAS SURVEY - Methodology

## 1.1 Concept

Soil gas monitoring is a cost effective means of delineating the size and movement of organic contaminants in the subsurface. The objective in measuring organic gases in soil is to map the lateral extent of soil and groundwater contamination. A constant sampling depth is used to acquire soil gas readings across the study site. The values are then plotted on a map and contoured. The result is a contour plot of soil gas concentrations at a constant depth across the site. This plot should be linearly related to contaminant concentrations in groundwater or impacted substratum.

mono-D:\MPR\PROJECT\2773.CRA\SOILGAS.RPT





Project #44.2773

## 1.2 <u>Technique</u>

LGI conducted the soil gas survey utilizing a portable percussion hammer to install the soil boreholes throughout the study area. A 7/8" diameter case hardened steel drill bit and probe were advanced to the desired depth at each sample location. An air tight soil gas sampling port (Figure 1) was then installed. The sampling port consists of a section of one-half inch diameter PVC piping perforated and open at the bottom. The sampling end of the PVC piping consists of an air tight triple size-reducing tube assembly terminating in a ribbed double hose connector. A peristaltic pump was attached to the hose connector to generate a negative pressure in the sampling port and to purge the borehole. As designed, air can only be drawn into the sampling port from the base of the borehole, thereby eliminating near surface gases from entering the apparatus. An organic vapor analyzer (OVA) and an HNu were utilized at each sampling location to obtain soil gas readings (Figure 2). The OVA and HNu are field screening flame ionization and photo ionization detectors, respectively, which are used to measure the total concentrations of volatile organic compounds (VOCs).

The sample port installation equipment was decontaminated between each boring with a liquinox wash, followed by a tap water rinse, followed by a deionized water rinse. At the end of each day of sampling, the boring equipment was also rinsed with methanol before the tap and deionized water rinses.

#### 2.0 WORK PLAN and DATA

LGI conducted a soil gas survey from February 5 through February 7, 1992. Fifteen (15) sample points (A series) were installed through the floor of the western warehouse, eighteen (18) sample points (B series) were installed through the floor of the eastern warehouse, ten (10) sample points (C series) were installed between the warehouse buildings, and seven (7) sample points (D series) were installed in the loading dock areas north of the buildings. Figure 3 provides the locations of the A, B, C, and D series sample ports. To monitor potential off-gases escaping from the penetrated warehouse subsurfaces, an explosimeter was utilized during borehole installations.

All sample port borings were installed to a depth of three (3) feet. The concrete floors inside the warehouses were approximately one (1) foot thick. Refusal was encountered at sample port location B19, at a depth of six (6) inches. The OVA and HNu readings are summarized in **Table 1** and illustrated on **Figures 4** through 6.

#### RIBBED DOUBLE HOSE CONNECTOR

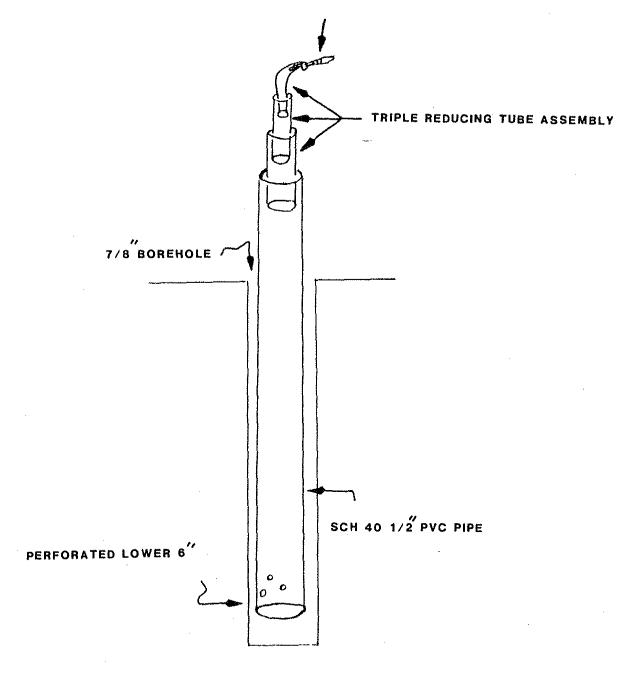


FIGURE 1: Soil Gas Sampling Port

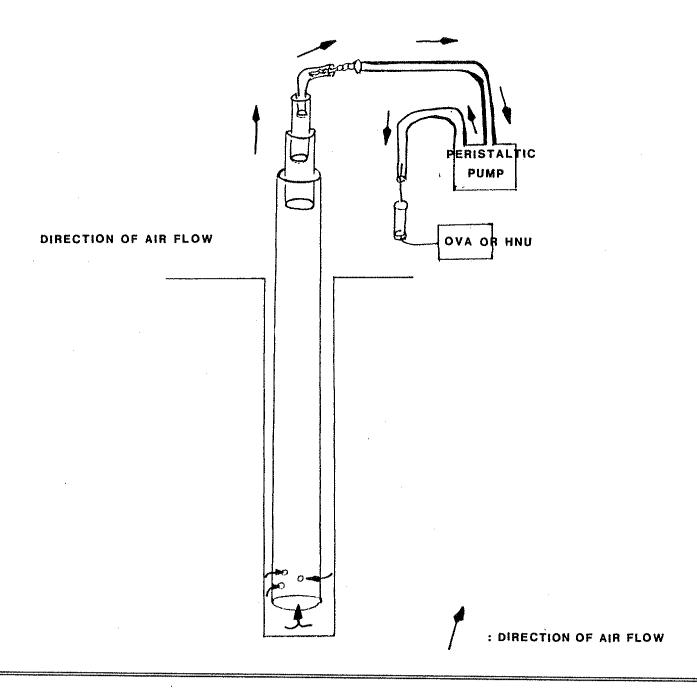
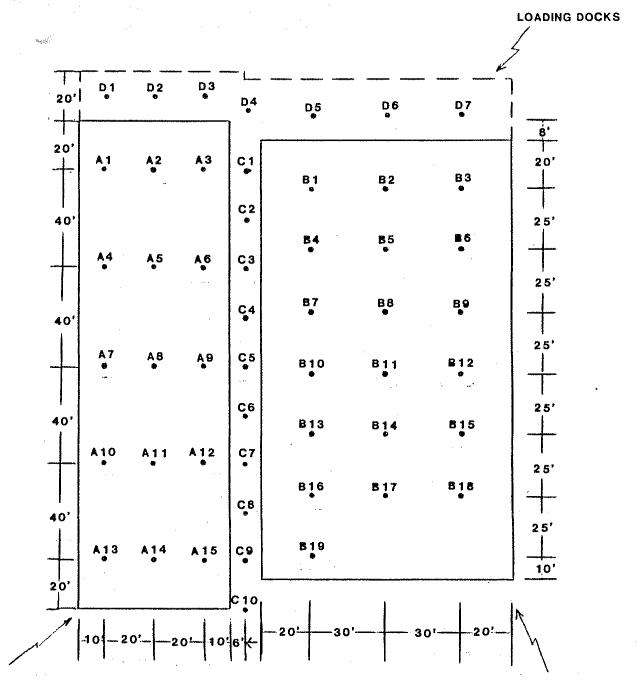


FIGURE 2: Soil Gas Sampling System



WESTERN WAREHOUSE

**EASTERN WAREHOUSE** 

A1 : SAMPLE POINT

SCALE 1" = 40'

FIGURE 3: SAMPLE LOCATIONS



TABLE 1
Summary of Soil Gas Survey Results

| <u>Location</u> | OVA Peak | OVA Stabilized | HNu Reading |  |
|-----------------|----------|----------------|-------------|--|
| A1              | 5.0      | 3.0            | 0.0         |  |
| A2              | 4.5      | 3.5            | 0.0         |  |
| A3              | 10.0     | 10.0           | 2.0         |  |
| A4              | 10.0     | 9.5            | 2.0         |  |
| A5              | 6.0      | 5.5            | 1.5         |  |
| <b>A</b> 6      | 65.0     | 50.0           | 1.0         |  |
| A8              | 0.5      | 0.5            | 0.0         |  |
| A7              | 0.0      | 0.0            | 0.0         |  |
| A9              | 5.0      | 4.5            | 1.0         |  |
| A10             | 1.5      | 1.0            | 0.0         |  |
| A11             | 0.0      | 0.0            | 0.0         |  |
| A12             | 0.5      | 0.5            | 0.0         |  |
| A13             | 0.5      | 0.0            | 0.0         |  |
| A14             | 1.0      | 1.0            | 0.0         |  |
| A15             | 0.0      | 0.0            | 0.0         |  |
| B1              | 0.0      | 0.0            | 0.0         |  |
| B2              | 8.0      | 6.5            | 0.5         |  |
| B3              | 4.0      | 3.5            | 0.0         |  |
| B4              | 3.5      | 3.0            | 1.0         |  |
| <b>B</b> 5      | 4.5      | 3.5            | 0.0         |  |
| <b>B</b> 6      | 9.5      | 4.0            | 0.0         |  |
| <b>B</b> 7      | 4.0      | 4.0            | 2.0         |  |
| <b>B</b> 8      | 5.0      | 4.0            | 2.0         |  |
| B9              | 10.0     | 4.5            | 1.5         |  |
| B10             | 5.5      | 3.0            | 1.0         |  |
| B11             | 3.0      | 2.0            | 1.5         |  |
| B12             | 10.0     | 5.0            | 1.5         |  |
| B13             | 3.5      | 3.0            | 0.5         |  |
| B14             | 3.0      | 3.0            | 0.5         |  |
| B15             | 3.0      | 2.5            | 0.0         |  |
| B16             | 25.0     | 6.0            | 2.5         |  |
| B17             | 7.5      | 4.5            | 1.0         |  |
| B18             | 7.0      | 4.0            | 1.0         |  |
| B19             | R        | R              | R           |  |
| C1              | 6.0      | 5.0            | 0.5         |  |
| C2              | 100.0    | 100.0          | 50.0        |  |
| C3              | 300.0    | 300.0          | 80.0        |  |
| C4              | 1.0      | 1.0            | 2.0         |  |
| C5              | 5.0      | 5.0            | 1.0         |  |
| C6              | 10.0     | 0.8            | 4.5         |  |
| C7              | 55.0     | 55.0           | 30.0        |  |
| C8              | 10.0     | 9.0            | 4.0         |  |
| C9              | 10.0     | 9.5            | 5.0         |  |
| C10             | 4.5      | 4.0            | 2.0         |  |
| D1              | 7.0      | 4.5            | 1.0         |  |
| <b>D2</b>       | 0.5      | 0.5            | 1.0         |  |
| D3              | 11,0     | 5.5            | 1.0         |  |
| D4              | 6.0      | 4.5            | 1.0         |  |
| D5              | 6.5      | 5.0            | 1.5         |  |
| $\mathbf{D6}$   | 0.5      | 0.5            | 0.5         |  |
| <b>D</b> 7      | 2.0      | 1.5            | 1.5         |  |

 $\label{eq:R} R \mbox{ = borehole refusal,} \\ OVA \mbox{ and } HNu \mbox{ readings are in parts per million.}$ 

| 1:0 | 1.0 | 1.0 | 1.0          | 1.5               | 0,5       | 1.5       |
|-----|-----|-----|--------------|-------------------|-----------|-----------|
| 0.0 | 0.0 | 2.0 | 0.5          | 0,0               | 0.5       | 0.0       |
| 2,0 | 1.5 | 1.0 | 50.0<br>80.0 | 1.0               | 0.0       | 0.0       |
|     |     | ·   | 2.0          | 2.0               | 2.0       | 1.5       |
| 0.0 | 0.0 | 1.0 | 1.0          | 1.0               | 1.5       | 1.5       |
| 0.0 | 0.0 | 0.0 | 4.5          | 0.5               | 0.5       | 0.0       |
|     | •   | •   | 4.0          | 2,5               | 1.0       | 1.0       |
| 0.0 | 0.0 | 0.0 | 5.0          | R<br>●            |           |           |
|     |     |     | 2.0          | · · <u>, , , </u> | EASTERN V | VAREHOUSE |

WESTERN WAREHOUSE

R : REFUSAL

0.0 : CONCENTRATION (PPM)

SCALE 1" = 40'

M

# FIGURE 4: HNu READINGS

|               |              |                |      | 4                 | •    |      |
|---------------|--------------|----------------|------|-------------------|------|------|
| 7.0           | 0.5          | 11.0           | 6.0  | 6.5               | 0,5  | 2.0  |
| 5.0           | 5.0 4.5 10.0 | 10.0           | 6.0  | 0,0               | 8.0  | 4.0  |
|               |              | 100            |      | r *               |      |      |
| 10.0 6.0 65.0 | 65.0         | 300            | 3.5  | 4.5               | 9.5  |      |
|               | .,           | <del>.</del> . | 1,0  | 4.0<br>•          | 5.0  | 10.0 |
| 0.5 0.0 5.0   | 5.0          | 5.0            | 5.5  | 3.0               | 10.0 |      |
|               |              |                | 10.0 | 3.5               | 3.0  | 3.0  |
| 1.5           | 0.0          | 0.5            | 55   | '                 | •    |      |
|               |              |                | 10.0 | 25.0              | 7.5  | 7.0  |
| 0.5           | 1.0          | 0.0            | 10.0 | R<br>•            | •    |      |
|               |              | 4.5            |      | EASTERN WAREHOUSE |      |      |

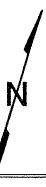
R : REFUSAL

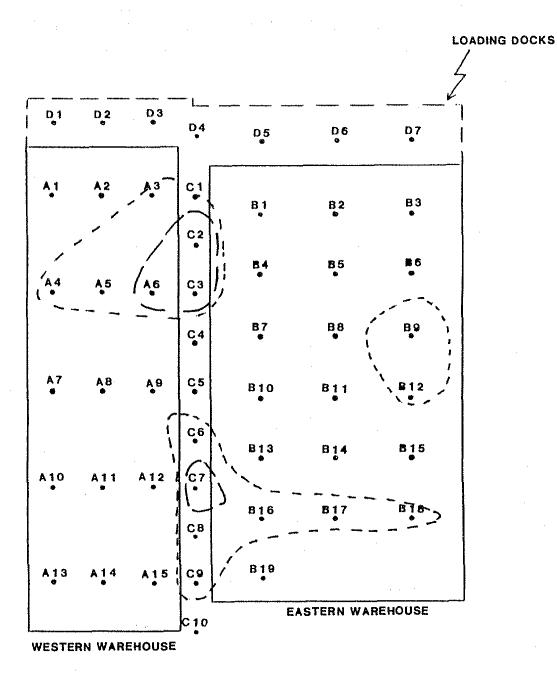
0.0 : CONCENTRATIONS (PPM)

SCALE 1" = 40'

FIGURE 6: OVA PEAK READINGS

WESTERN WAREHOUSE





A1 : SAMPLE POINT

SCALE 1" = 40'

: SUSPECT AREAS

: AREAS OF HIGHEST DETECTED CONCENTRATIONS

FIGURE 7: Suspect Areas





The OVA peak reading is the initial response to the soil gas, which presents the highest contaminant concentration. The peak OVA reading is obtained immediately after borehole installation. The stabilized reading represents the "steady" soil gas concentration after the release of any built-up gases from the subsurface.

#### 3.0 <u>CONCLUSIONS</u>

The range of VOC concentration values for the OVA - peak, OVA - stabilized, and the HNu, were 0 to 300, 0 to 300, and 0 to 80 ppm, respectively. Correspondingly, the means were 15.21, 13.47, and 4.21 ppm. Ten percent (5 entries) of the OVA - peak and HNu readings were above their respective means. Eight percent (4 entries) of the OVA stabilized readings were above the mean. Three above mean sample port locations were common to all three sets of results, namely C2, C3, and C7. A6 was above the mean for both sets of OVA results. These locations have been labelled as "areas of highest detected concentrations" on Figure 7. Secondary suspect areas have also been outlined according to relative detected VOC concentrations.

LGI recommends investigating the three (3) suspect areas outlined in Figure 7 by utilizing a combination of ground penetrating radar (GPR) and backhoe excavations. These areas should be surveyed with GPR, followed by the excavation of the areas located between the warehouse buildings via a small backhoe or skid loader.

If you have any questions concerning this project, or the conclusions presented in this report, please do not hesitate to call.

Sincerely,

LGI, a division of Layne GeoSciences, Inc. Environmental and Groundwater Scientists

Michael P. Raffoni

Project Manager

# APPENDIX D

# APPENDIX D

LGI SEISMIC REFRACTION SURVEY REPORTS

# Project #44.2722

# SEISMIC INVESTIGATION

near the

# OLIN CHEMICAL FACILITY WILMINGTON, MASSACHUSETTS

# Prepared for:

CONESTOGA-ROVERS AND ASSOCIATES 1801 OLD HIGHWAY 8, SUITE 114 ST. PAUL, MN 55112

FEBRUARY - APRIL 1992

Project #44.2722

# **SEISMIC INVESTIGATION**

near the

# OLIN CHEMICAL FACILITY WILMINGTON, MASSACHUSETTS

# Prepared for:

CONESTOGA-ROVERS AND ASSOCIATES
1801 OLD HIGHWAY 8, SUITE 114
ST. PAUL, MN 55112

FEBRUARY - APRIL 1992



#### 1.0 OVERVIEW

During February, 1992, LGI, a division of Layne GeoSciences, Inc., conducted a seismic refraction investigation within the swamp area west of the Olin Chemical facility, Wilmington, Massachusetts (see Figure 1). The purpose of the geophysical investigation was to delineate bedrock topography in an area approximately 3500 feet west of a previous study undertaken by LGI (October, 1991). The existence of a buried, bedrock channel is suggested from the previous report submitted by LGI to Conestoga-Rovers & Associates (CRA). Four cross-sectional traverses totaling 4540 linear feet and three individual seismic refraction profiles were collected during the February, 1992, seismic investigation. Seismic data interpretation revealed that the bedrock morphology is channelized and appears to deepen to the northwest.

#### 2.0 THEORY AND FIELD DESIGN

## 2.1 Theory

#### **SEISMIC REFRACTION**

The seismic refraction method involves measuring the direct path taken by sound waves as they propagate within the subsurface away from the seismic source. Ground movement is detected by the geophones and recorded on the seismograph for subsequent interpretation. From these responses, compressional-wave velocities are calculated and the depth to subsurface interfaces is determined.

Sound waves travel at different rates through dissimilar materials (i.e., greater sound velocities attained through more solid, denser media). Insight on the relative hardness of subsurface materials can be predicted from the seismic method and this is necessary in order to provide information concerning subsurface depths and contrasts in lithology.

Project No. 2722 Page 2

#### SEISMIC REFLECTION

The seismic reflection method involves measuring sound energy as it reflects off subsurface interfaces and returns to the surface. Seismic reflections are generally observed along seismic lines within a narrow "window". A seismic reflection window consists of those geophone locations which fall within the area where primary seismic reflections can be best recorded. A seismic window (if present) generally falls approximately twice the bedrock depth away from the energy source. By utilizing overburden velocities determined from seismic refraction data, the depth to bedrock within the reflection window is resolved.

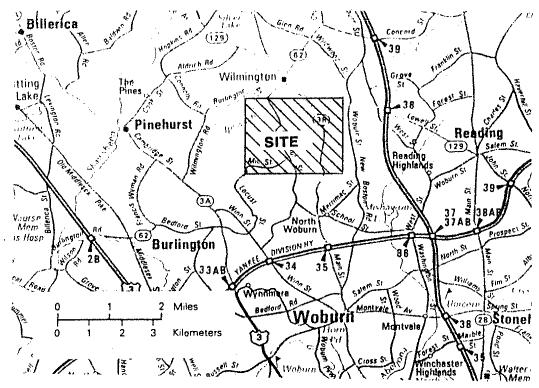
#### 2.2 Instrumentation

LGI conducted the seismic study with similar parameters and instrumentation used during the October, 1991, survey. All seismic lines consisted of twenty-four (24) sound receivers (geophones) spaced at ten foot intervals. The seismic source consisted of a black powder packed 10 gauge shot. Seismic data was recorded on a 24-channel seismograph. Downloading of the field records to a computer was performed for subsequent data reduction and interpretation.

# 2.3 Field Design

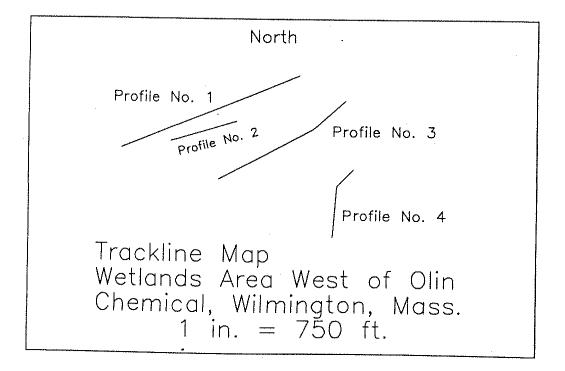
Twenty-one seismic lines were acquired within the study area. Three of these lines (10 - 12) were collected in an industrial area east of the Olin site. A seismic source offset (ranging from 20-80 feet) was used to profile subsurface interfaces within 100 feet of the surface. The four seismic traverses were oriented nearly parallel to one another in a southwest-northeast direction (see Figure 2). The profile numbering system used in this report is based on lateral position and is not the order in which the traverses were collected. Adjacent seismic lines were overlapped between 20 and 40 feet to provide more complete bedrock coverage. All shotpoint locations were labeled and flagged for subsequent surveying.





# SITE LOCATION MAP

# FIGURE 2:



# PROFILE LOCATION MAP



#### 3.0 RESULTS

## 3.1 <u>Data Interpretation</u>

Bedrock depths were resolved utilizing standard seismic refraction and reflection software. Upon close examination of the seismic data, the presence of bedrock reflections was noticed. Although survey parameters were not specifically designed to detect seismic reflections, the geologic conditions and survey parameters resulted in high quality bedrock reflections along several seismic lines. In many cases, the swamp conditions and poor weather conditions dampened seismic refraction arrivals, although reflections were present.

Seismic data interpretation coupled with a velocity analysis yielded two distinct geologic layers for the cross-sectional profiles generated in this report. Overburden velocities ranged from 3400-6000 ft/s (unconsolidated, water-saturated, sediments) and crystalline bedrock velocities were calculated to range from 13,000-18,000 ft/s.

The depth to bedrock information determined from the seismic data was combined with surface elevation data (provided by CRA) to generate cross-sectional profiles (see Figures 3 - 6). The profiles are a two-dimensional representation of the overburden/bedrock interface below the land surface along each traverse. Irregular features displayed on the bedrock surface are due to the nature of the interpretive software and are not as abrupt in actuality. Except where noted, seismic refraction data interpretations were used as final depth determinations.

## 3.2 Profile No. 1

Seismic Profile No. 1 was the northernmost traverse acquired within the study area (see Figure 3). Depths to bedrock range from at least 38 feet to a maximum of 95 feet. The bedrock surface appears channelized along the southwestern portion of this traverse. Seismic data quality for Profile No. 1 was good and the velocity values calculated appear to match the described lithologies for this area. Seismic reflection data interpretations were used for shot records 1F, 2F, 2R, 3F, 3R, 4F, 4R2 & 7F.



#### 3.3 Profile No. 2

A second seismic profile was positioned approximately 150 feet southeast of Profile No. 1 (see **Figure 4**). Data quality was poor along this traverse due to windy weather conditions. Interpretation is suspect for Profile No. 2. Velocity values appear consistent with the other profiles, but the depths to bedrock and morphology do not agree with the other traverses. The bedrock surface along Profile No. 2 appears flat-floored with a minimum of 30 feet of sediment overlying bedrock. Seismic reflection data interpretations were used for shot record 21R.

#### 3.4 Profile No. 3

A channel-like feature on the bedrock surface was interpreted along Profile No. 3 (see Figure 5). This traverse is located approximately 600 feet southeast of Profile No. 1. Data quality of Profile No. 3 is fair, but some of field records were noisy making interpretation of the seismic data difficult. Velocity ranges for this profile appear reasonable for the overburden and bedrock. Bedrock appears to deepen towards the central portion of the traverse and maximum depth to bedrock is reported at 61 feet. Along the southwestern margin of the profile bedrock appears to shallow to a depth of 14 feet. Seismic reflection data interpretations were used for shot records 9F, 9R, 13F & 13R.

## 3.5 Profile No. 4

Profile No. 4 was acquired approximately 1200 feet southeast of Profile No. 1 (see Figure 6). Bedrock appears channelized in cross-section with a maximum depth of 102 feet projected to bedrock near the north edge of the profile. Data quality was generally poor due to weather conditions. Only six data points were plotted for the bedrock surface profile because of poor data quality. Reasonable velocity values were generated from interpretable data providing confidence in the interpretation of Profile No. 4. Seismic reflection data interpretations were used for shot records 19F & 19R.



Project No. 2722 Page 5

#### 3.6 Profiles East of Olin Site

Three separate seismic lines were collected east of the Olin facility along Woburn Avenue and Presidential Road. The bedrock surface below seismic lines 10, 11, & 12 ranged from thirty to forty-five feet. Overburden velocities ranged between 2600 - 4000 ft/s. Bedrock velocities ranged between 9000 and 16400 ft/s. Industrial machinery in surrounding buildings contributed substantial seismic noise. Surface elevations were not known; a value of 100 feet was used for all surface elevations when constructing the bedrock profiles. Bedrock profiles for these seismic lines are included in Appendix A.

#### 4.0 ASSESSMENT

The results of this investigation were compared with those from the October 1991 seismic refraction survey. As stated previously, the buried bedrock valley appears to deepen to the northwest. Although the traverses are laterally separated, certain comparisons can be made. The survey in October 1991 encountered varying degrees of cultural seismic noise (noise) in all areas of the site. The effects on the seismic velocity analysis were not fully known until certain seismic lines (4R, 5F, 5R2 & 6F) from the February 1992 survey were interpreted. These lines displayed virtually no external seismic interference, allowing both overburden and bedrock velocities to be calculated with high confidence. The bedrock velocities under these seismic lines were found to be much higher than most velocities resolved from the October 1991 survey, while the overburden velocities in the swamp are consistent with saturated porous sediment velocities.

When entered into the equation used to determine depth from seismic refraction data, a higher bedrock velocity will resolve the bedrock surface at a deeper depth, provided all other factors are constant. The presence of seismic noise during the October 1991 survey may have masked true refraction arrivals and resulted in slower bedrock velocities. This is possible since ground truths, determined from drilling since the October 1991 survey, reveal that the bedrock surface is actually deeper in many places than the seismic refraction interpretations resolved.



## 5.0 CLOSING

The field procedures and interpretive methodologies used in this project are consistent with standard, recognized practices in geophysical surveying. This warranty is in lieu of all warranties either implied or expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

# FIGURE 3:

Seismic Profile No. 1 (Study Area West of Olin Chemical, Wilmington, Mass.)

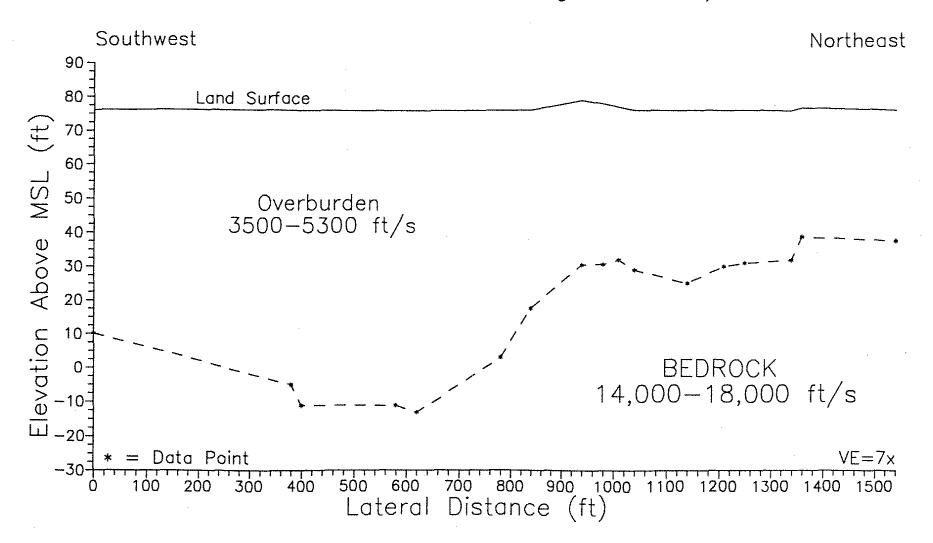
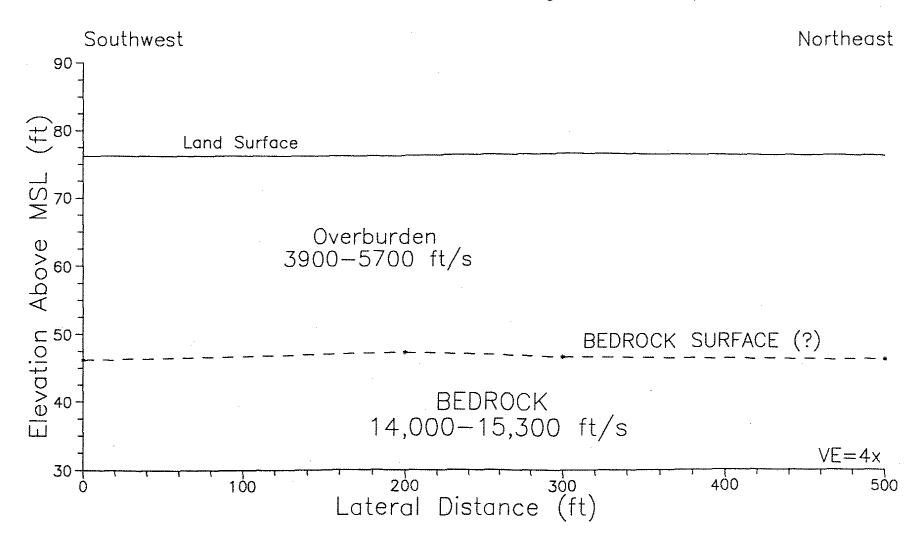


FIGURE 4:

Seismic Profile No. 2 (Wetlands Area West of Olin Chemical, Wilmington, Mass.)



# FIGURE 5:

# **REVISED**

Seismic Profile No. 3 (Study Area West of Olin Chemical, Wilmington, Mass.)

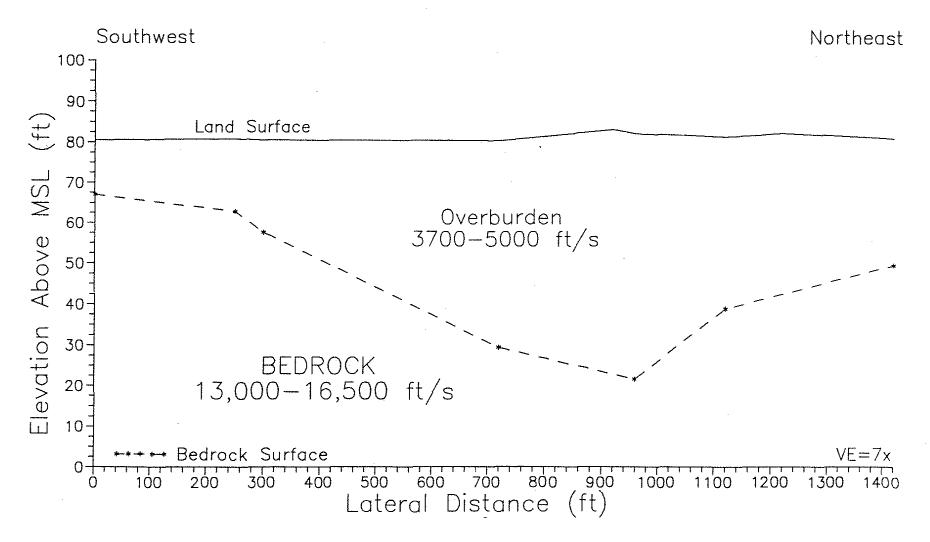
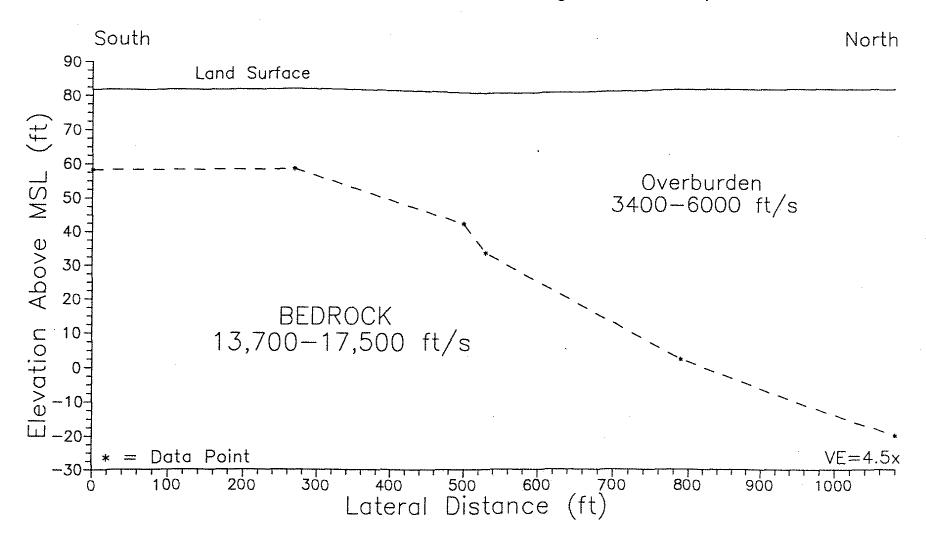


FIGURE 6:

Seismic Profile No. 4 (Study Area West of Olin Chemical, Wilmington, Mass.)





## 3.3 <u>Profile No. 2</u>

A second seismic profile was positioned approximately 150 feet southeast of Profile No. 1 (see Figure 4). Data quality was poor along this traverse due to windy weather conditions. Interpretation is suspect for Profile No. 2. Velocity values appear consistent with the other profiles, but the depths to bedrock and morphology do not agree with the other traverses. The bedrock surface along Profile No. 2 appears flat-floored with a minimum of 30 feet of sediment overlying bedrock. Seismic reflection data interpretations were used for shot record 21R.

## 3.4 Profile No. 3

A channel-like feature on the bedrock surface was interpreted along Profile No. 3 (see Figure 5). This traverse is located approximately 600 feet southeast of Profile No. 1. Data quality of Profile No. 3 is fair, but some of field records were noisy making interpretation of the seismic data difficult. Velocity ranges for this profile appear reasonable for the overburden and bedrock. Bedrock appears to deepen towards the central portion of the traverse and maximum depth to bedrock is reported at 61 feet. Along the southwestern margin of the profile bedrock appears to shallow to a depth of 14 feet. Seismic reflection data interpretations were used for shot records 9F, 9R, 13F & 13R.

## 3.5 Profile No. 4

Profile No. 4 was acquired approximately 1200 feet southeast of Profile No. 1 (see Figure 6). Bedrock appears channelized in cross-section with a maximum depth of 102 feet projected to bedrock near the north edge of the profile. Data quality was generally poor due to weather conditions. Only six data points were plotted for the bedrock surface profile because of poor data quality. Reasonable velocity values were generated from interpretable data providing confidence in the interpretation of Profile No. 4. Seismic reflection data interpretations were used for shot records 19F & 19R.



#### 3.6 Profiles East of Olin Site

Three separate seismic lines were collected east of the Olin facility along Woburn Avenue and Presidential Road. The bedrock surface below seismic lines 10, 11, & 12 ranged from thirty to forty-five feet. Overburden velocities ranged between 2600 - 4000 ft/s. Bedrock velocities ranged between 9000 and 16400 ft/s. Industrial machinery in surrounding buildings contributed substantial seismic noise. Surface elevations were not known; a value of 100 feet was used for all surface elevations when constructing the bedrock profiles. Bedrock profiles for these seismic lines are included in Appendix A.

#### 4.0 ASSESSMENT

The results of this investigation were compared with those from the October 1991 seismic refraction survey. As stated previously, the buried bedrock valley appears to deepen to the northwest. Although the traverses are laterally separated, certain comparisons can be made. The survey in October 1991 encountered varying degrees of cultural seismic noise (noise) in all areas of the site. The effects on the seismic velocity analysis were not fully known until certain seismic lines (4R, 5F, 5R2 & 6F) from the February 1992 survey were interpreted. These lines displayed virtually no external seismic interference, allowing both overburden and bedrock velocities to be calculated with high confidence. The bedrock velocities under these seismic lines were found to be much higher than most velocities resolved from the October 1991 survey, while the overburden velocities in the swamp are consistent with saturated porous sediment velocities.

When entered into the equation used to determine depth from seismic refraction data, a higher bedrock velocity will resolve the bedrock surface at a deeper depth, provided all other factors are constant. The presence of seismic noise during the October 1991 survey may have masked true refraction arrivals and resulted in slower bedrock velocities. This is possible since ground truths, determined from drilling since the October 1991 survey, reveal that the bedrock surface is actually deeper in many places than the seismic refraction interpretations resolved.



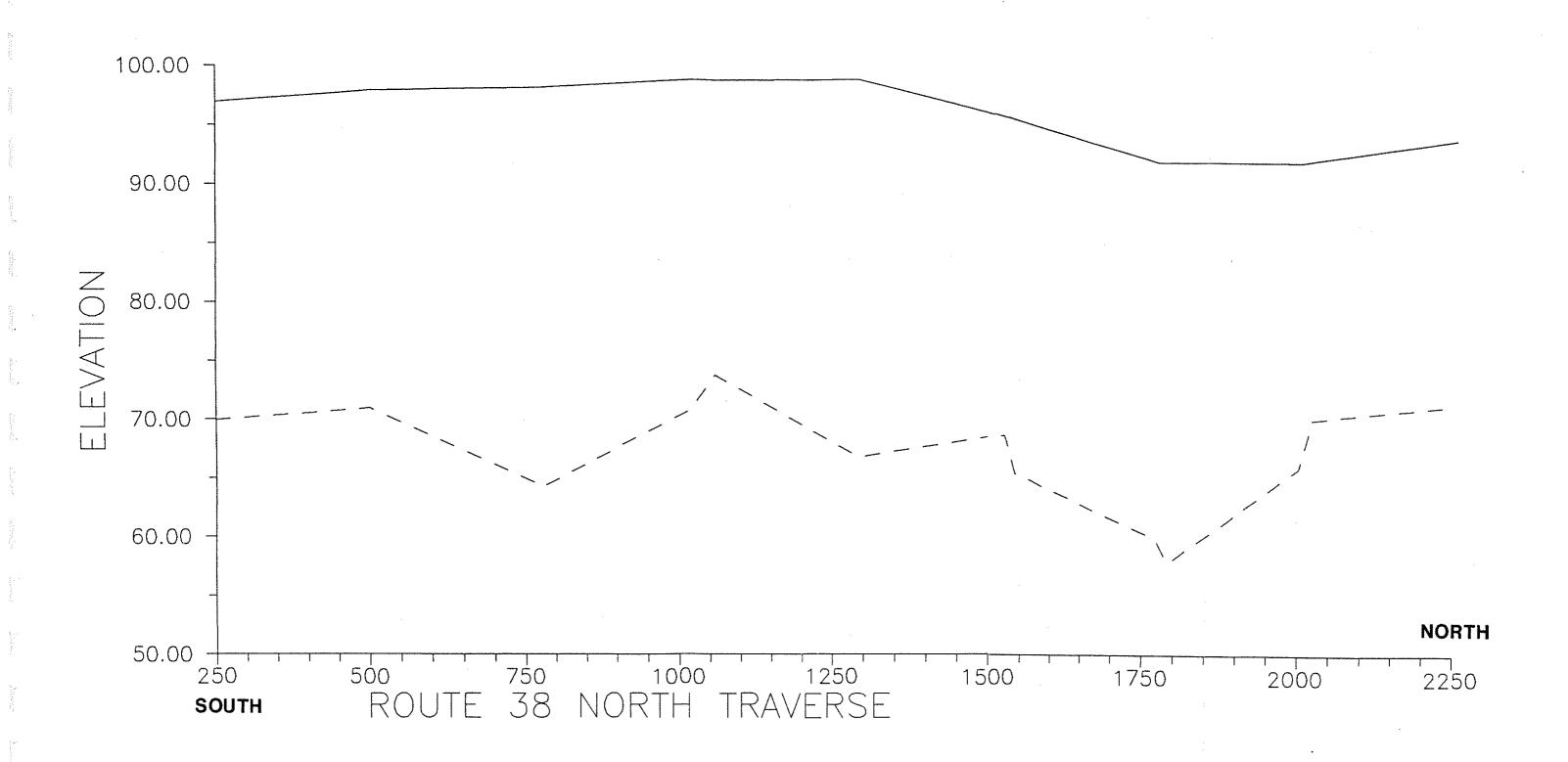
## 5.0 CLOSING

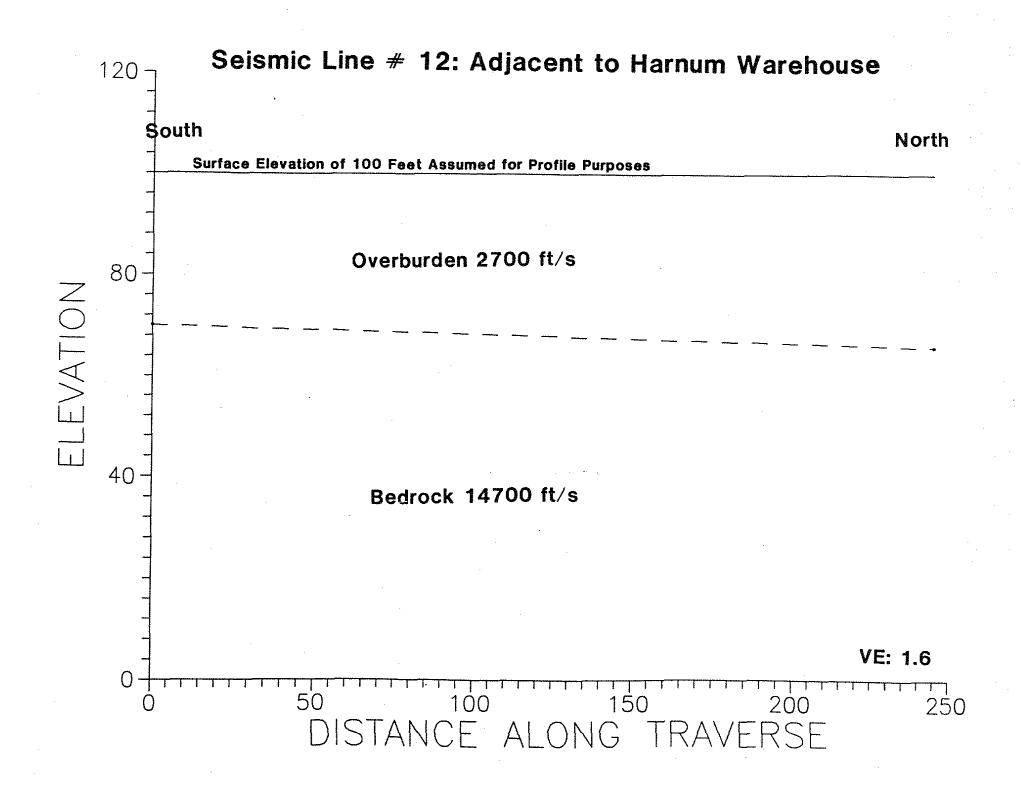
The field procedures and interpretive methodologies used in this project are consistent with standard, recognized practices in geophysical surveying. This warranty is in lieu of all warranties either implied or expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.



# APPENDIX A

INDIVIDUAL PROFILES EAST OF OLIN SITE





A Division of Layne GeoSciences, Inc.

PROJECT #44.2628

## **GEOPHYSICAL INVESTIGATION**

AT THE

OLIN CHEMICAL FACILITY WILMINGTON, MASSACHUSETTS

PREPARED FOR:

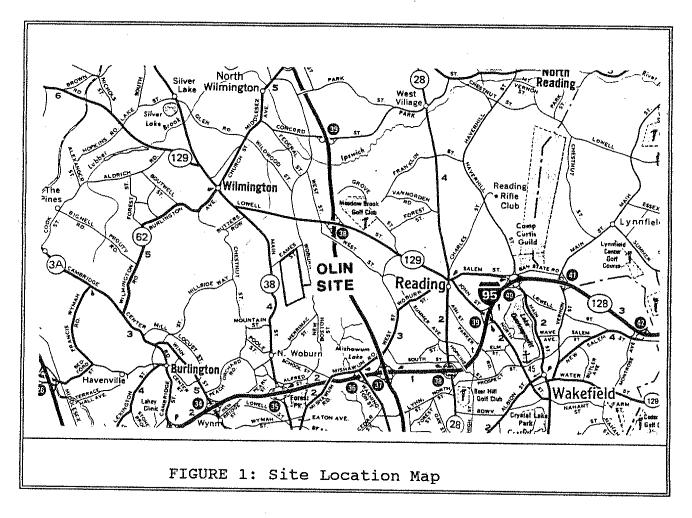
CONESTOGA - ROVERS 382 WEST COUNTY ROAD D ST. PAUL, MN 55112

NOVEMBER 1991



#### 1.0 OVERVIEW

On October 7<sup>th</sup>-10<sup>th</sup>, 12<sup>th</sup>-14<sup>th</sup>, 1991, LGI, a division of Layne GeoSciences, Inc., performed a seismic refraction investigation near the Olin Chemical facility in Wilmington, Massachusetts (see Site Location Map). The purpose of the investigation was to profile the bedrock surface to determine the existence and extent of a possible bedrock valley near the Olin facility. The proposed traverses were located in an industrial area. As a result, a significant amount of cultural seismic noise (traffic, compressors, equipment, etc.) was anticipated.





#### 2.0 METHODOLOGY AND FIELD DESIGN

#### 2.1 Theory and Instrumentation

The seismic method involves the transmission of sound waves into the earth, and recording the earth's resulting response at set distances from the seismic energy "source"; this process constitutes one "seismic line". Each seismic line consists of twenty-four (24) receivers (geophones) which record the seismic energy (see Figure 2).

The seismic data is reduced and interpreted yielding a two-dimensional model of the subsurface. One two-dimensional model is derived from each seismic line. Because sound waves travel at different rates through dissimilar materials (i.e., faster through harder and denser materials), an insight to the relative hardness of subsurface materials can be discerned. Consequently, the seismic method furnishes information concerning the depth and relative strength or nature of subsurface materials.

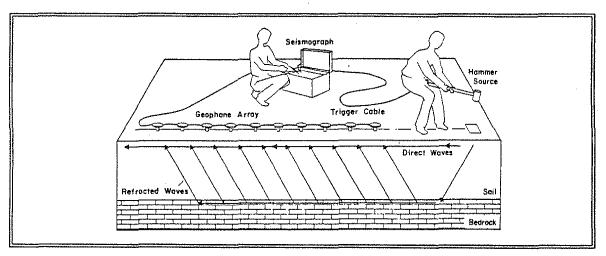


Figure 2: Generalized seismic line diagram.

# 2.2 Seismic Field Design

Approximately 1150 depth points were generated via the seismic refraction method by locating 48 seismic data acquisition lines (seismic lines) over the site. To ensure a depth of exploration of at least 70 feet, most seismic lines were designed with a ten foot geophone (receiver) spacing and a ten foot source offset. In addition, five seismic lines (32, 33, 43, 44 & 48) were collected utilizing five foot geophone spacings and offsets to better resolve contrasts in areas of shallower bedrock.



Seismic lines were located along five primary traverses: Eames St., Jewel Dr., Route 38 North & South, and along the railroad tracks west of the Olin site. In most cases, seismic lines were overlapped twenty feet to provide more complete bedrock coverage. In addition several other individual lines were distributed throughout the area to provide bedrock information in the region. Seismic lines were placed primarily on the street and railroad right-of-ways. Seismic lines which were not a part of the traverses were placed in relatively open and accessible areas. See Figure 3 for approximate seismic line locations.

#### 3.0 INTERPRETATION

As expected, the seismic data analysis yielded a complex bedrock surface. The depth to bedrock information determined from the seismic refraction has been combined with surface elevation data (provided by CRA) to produce seismic cross-sections below each traverse and each isolated seismic line. As revealed by the **Bedrock Profiles** (Appendix A), the depth to bedrock ranges from under six feet (6') to over forty feet (40') below the existing land surface. As a result of the seismic line geometry utilized for the investigation, the bedrock depth accuracy is +/- five feet (5'). Cultural noise presented many difficulties during the field and interpretative phases of the investigation. Several cultural interferences (traffic, compressors, etc.) produce vibrations which are within the frequency range of the refracted seismic data. As a result, refracted waveforms can become distorted. to increase the signal-to-noise ratio during data collection, 10 gauge shotgun shells were utilized as a Multiple shots were also collected at several locations. source. Final seismic line interpretations were completed after referencing adjoining lines (along the same traverse) to ensure consistent transitions.

The Bedrock Profiles represent the bedrock surface directly below the existing grade along each traverse. The sharp features displayed on the bedrock profiles are due to the nature of the interpretative software and are not as abrupt in actuality. All mapped bedrock is considered competent; however, there may be pockets of rippable, decomposed rock scattered throughout the site.

The seismic refraction investigation revealed the presence of a valley feature extending to the west-northwest of the Olin plant. The valley is most prominent near the origin on the Route 38 South (W) traverse. Bedrock is also relatively deep below Eames Street leading



west towards the Route 38 Intersection. Several other relative lows exist along the traverses, although none dip below the elevation of the valley at the Eames Street and Route 38 intersection.

## 4.0 CLOSING

The field procedures and interpretative methodologies used in this project are consistent with standard, recognized practices in geophysical investigations. This warranty is in lieu of all other warranties either implied of expressed. LGI assumes no responsibility for interpretations made by others based on work performed by or recommendations made by LGI.

## APPENDIX A

## **BEDROCK PROFILES**

## **LEGEND**

**SOLID LINES: Existing Topography** 

DASHED LINED: Bedrock Surface (unless noted otherwise)

